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MAPPING THE RESEARCH OUTPUT OF “JOURNAL OF BIOSCIENCE AND BIOENGINEERING” (2007-2016) : A SINGLE JOURNAL SCIENTOMETRIC STUDY

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I. Introduction

The term “bibliometrics” was first defined by Pritchard in 1969 as “the application of mathematical and statistical methods to books and other media” (p. 349). It involves the analysis of a set of publications, characterized by bibliographic variables such as the author(s), the place of publication, the associated subject keywords, and the citations.

The terms ‘Librametrics’, ‘scientometrics’, and ‘informetrics’ are also in use in the literature. Bibliometrics is analogous to ‘Ranganathans’, ‘Librametrics’, Russian concept ‘scientometrics’, FID’s ‘Informetrics and also to some other well established sub disciplines like ‘Econometrics’, ‘Psychometrics’, ‘Sociometrics’ and ‘Biometrics’ where mathematical and statistical calculus have been systematically applied to study and solve the problems in the field of library science, history of science, information science, economics, psychology, sociology and biology respectively (Akhtar & Nishat, 2011).

Scientometrics is a field of science dealing with the quantitative aspects of individual researcher, team, funding, technological input and scientific output but which do not primarily fall within the scope of a particular discipline. The aim of Scientometrics is to reveal characteristics of scientometric phenomena and processes in scientific research for more efficient management of science. Scientometrics is also considered as bibliometric measurement for evaluation of scientific development, social relevance and impact of application of science and technology etc. Scientometrics is now used for the application of quantitative methods to the history of science and overlaps with bibliometrics to a considerable extent. (Thanuskodi, 2010)

Scientometrics analyzes the quantitative aspects of the generation, propagation and utilization of scientific information in order to contribute to a better understanding of the mechanism of scientific research activities.

According to Van Raan “Scientometric research is devoted to quantitative studies of science and technology” (Van Raan, 1997).

II. Journal of Bioscience and Bioengineering



The Journal of Bioscience and Bioengineering (JBB) aims to contribute to the advancement and dissemination of knowledge and technology in the fields of bioscience and biotechnology. JBB publishes papers on a broad range of topics in the areas of enzymology, physiology and biotechnology of microbes, plants, and animals; genetics, molecular biology, and gene engineering; brewing and food technology; environmental biotechnology; biochemical engineering; cell and tissue engineering; protein engineering; biomedical engineering; and bioinformatics. Genomics, systems biology, and structural biology, which hold much promise for the future, are also within the scope of JBB. The journal is published by the Society for Biotechnology, Japan and Distributed outside Japan by Elsevier (<http://www.sbj.or.jp/e/>).

III. Review of Literature

Ghar and Urkudkar (2016) did a bibliometric study on "Journal of Biosciences" for the period 1979 to 2015 and revealed that maximum number of citations 3988 (5.67 %) were produced in 2007. The maximum (20390, 28.99%) citations involved just two authors.

Gogoi and Barooah (2016) conducted a bibliometric study on “Indian Journal of chemistry” and found that authorship trend is towards team works rather than a work in isolation Most of the publications cited are articles in journals; the number of references in other kinds of documents such as books/monographs, conference proceedings, theses/dissertation etc. are small. Among the citations from journal literature, majority are from foreign journals though the journals of Indian origin have also extensively used by the researchers. The most frequently cited journal titles were Tetrahedron Letter, Journal of Medicinal Chemistry and Journal of Organic Chemistry. The year wise distribution of the cited documents reveals that

publications of pre 1950s still continue to be cited in the source journal. The year-wise distribution of journals indicated that journals published from 2000 – 09 are highly preferred.

Maity and Teli (2015) analysed the “Malaysian Journal of Library and Information Science 2010 to 2014” covering 114 articles published during 2010 – 2014 and revealed that: the maximum number of articles (28) was published in 2011. There has been slight decrease in the number of articles published from 2012 to 2014. Maximum numbers of contributors (48) are joint authored. The highest (72) contributions are from Malaysia and Zainab Awang Ngah has published maximum no. of articles (13) in the journal. Majority of the authors preferred periodicals as the source of citation.

Padma and Ramasamy (2015) undertook a bibliometric study of contributions found in the ‘Malaysian Journal of Library and information science’ during the years 2007-2012 and found that year 2011 has the most number of articles i.e. 28 (23.73 %) and the year 2007 has the least number of articles i.e. 14 (11.86 %). 27.5 % of the articles were single authored, 42.5% of the articles were two authored and 22% of them were three authored. The overall degree of collaboration for the period 2007-2012 is 0.725. 44 (36.67 %) articles were in the page range of 16-20 followed by 43 articles within the page range of 11-15. 45% (54) of the articles used 21-40 references and 37.5% of the articles used up to 20 references. 26 articles (21.67 %) were published in the subject statistical studies followed by 14 on user studies (11.86 %) and 11 on Scientometric studies (9.322 %). University of Malaysia tops with 28 articles constituting 23.33 % of articles published, followed by Bhabha Atomic Research Centre and Islamic Azad University with 6 articles each (5.0 %). Zainab A N has emerged as the most prolific author with 14 articles (11.86 %) followed by Abrizah A with 8 articles (6.78 %) as the second prolific author.

Verma, Sonkar and Gupta (2015) did a bibliometric study of the E-Journal, ‘Library Philosophy and Practice’ for the period 2005 to 2014 and showed that on an average, 117 articles were published each year. Single authorship is leading authorship trend but also two authored articles have shown good number of contribution with the 0.51 rate of degree of collaboration.

Gudodagi and Manjunatha (2014) evaluated the publication and reference patterns in the PEARL - A Journal of Library & Information Science from 2007-2013 and found that only few research papers were published by the foreign authors. Andhra Pradesh contributed maximum number of papers followed by Karnataka and Tamil Nadu. These three south

Indian states contributed 66% of the total papers. The maximum numbers of contributors are two authors with 42.12 %. The average length of the research papers is 7 pages. The average number of 10 references per paper indicates that the authors review a significant amount of literature before writing a paper. The study also shows that almost all research papers include a brief abstract.

Mamdapur, Rajgoli and Chavan (2014) analyzed articles published in SRELS Journal of Information Management during the years 2004-2013 and brought out that the journal self citation is 7.11% which brings it to the 1st rank in the ranked list of journals preferred by the authors. Authors have mainly depended on journals (44.49%) and books (22.51%) as their preferred choice of information sources. The shift from print to electronic and the authors' choice of electronic resources has made Web Pages (15.60%) as other important source of information. Nearly 51.00% of articles have a page range of 6-10 pages. The highest contributions are two-authored (51.70%) followed by single authored (34.70%). The collaborative measures are calculated as per Ajiferuke et al (0.35), Lawani (2.28) and Subramanyam (0.65). The distribution of journal citations confirms to Bradford's law of distribution through Leimkuhler model.

Mishra (2014) presented a bibliometric analysis of the 'Health and Population: Perspectives Journal' during the year 2001-2010 and revealed that the maximum 34 (13.39%) papers were published in the year 2008 and the mean number of published papers per year was 23.09. Majority of contributions appeared under contraception (27, 10.63%) while the next position was taken by health policy/programmes by 19 (7.48%) articles. Majority of articles 127 (50%) were contributed from Delhi state and only 1 (0.39%) article has been contributed from each of Assam, Goa, Himachal Pradesh, Meghalaya and West Bengal. Contribution from foreign countries has also been counted as 4 (1.57%) articles. Maximum number of citations accounted for the period of study were 441 (13.61%) citations reported in 2010 while the minimum 193 (5.95%) were found in year 2000.

Pandita (2014) carried out a bibliometric study on 366 scholarly research articles published in 'DESIDOC Journal of Library and Information Technology, during the period 2003-2012 and found that maximum of 147 articles contributed in the journal are on two author pattern, followed by 139 articles as single author. New Delhi is the single largest contributing state with 199 out of 627 contributors from India. On average 6.20 articles were published by the

journal in each issue during the period of investigation with total references 5063, thereby making average 13.83 references each article.

Thanuskodi (2014) made a study on the bibliometric analysis of “D-Lib Magazine” for the period 2003 – 2012 and showed that out of 361 articles, joint authors contributed 241 (66.75%) articles while the rest 120 (33.25%) articles were contributed by single author. The highest contributions were from universities (147, 40.73%) followed by research institutions (82, 22.71%) and Colleges (65, 18.00%). The remaining 67 articles (18.56%) were contributed by other agencies like public organizations etc. Majority of the contributors preferred journals as the source of information which occupied the top position with the highest number of citations (3656, 49.36%) of the total 7407 citations followed by Seminar / Conference Proceedings with 1315 (28.68%) citations

Vijayanathan and Kaliyamoorthi (2014) did a bibliometric study on the articles published in the open Software Engineering Journal from 2007-2012 and showed that majority of papers are multi authored. The degree of collaboration is found to be 0.75. The contribution by Finland and Canada is the highest in foreign. Maximum number of articles is 6 (37.50%) which have been contributed by Two authors. Single author research works were low among the contributions made to the open software engineering journal. The Geographical distribution of papers highlights that the journal is dominated by the host country (i.e. foreign).

Abiolu (2013) undertook a bibliometric study of ‘Studies in Family Planning journal’ from 2004 to 2009 and revealed that family planning and sexual and reproductive health were key subjects of research. Authors tilted towards collaboration. Most authors were affiliated to universities. The most cited information source was journal. Most of the articles were on developing countries and most authors were domiciled in developed countries with USA dominating the field. The gender of the author shows that 37.9% were male and 32% were female but the gender of others could not be ascertained. The degree of collaboration is 0.74. Research publication is highest in universities with 51% of the articles emerging from them. Looking at the citation patterns, journal (56.3%) and monograph (25.6%) are the highest used information sources in the study. Africa (43.7%) attracted more articles than others with Asia having (29.6%). USA is the leading country with respect to research in family planning and sexual and reproduction.

Barik and Jena (2013) made a bibliometric analysis on 'Journal of Knowledge Management Practice' 2008-2012 and revealed that in the year 2011, highest 42(23.3%) articles were published out of 180 articles in 5 years. Single author contribution is predominant with 42.7%. Average numbers of citations per article are 19. USA has contributed 34 articles with 18.8% and highest 69.4% articles are published with page range of 11-20. Padma and Ramasamy (2013) carried out a bibliometric study of the journal "Journal of Information Literacy" (2007-2012) - a free online journal. The study focused on the authorship pattern, types of publications, citation study, no. of pages, institution-wise output, country-wise output, the degree of collaborative research, degree of collaboration, year-wise and volume-wise contributions etc.

Chandran (2013) presented a bibliometric study on research trends in 'Journal of Intellectual Property Rights' (JIPR) between 2007 and 2012 and found that the highest number of contributions i.e., 56 (19.79 %) were published in the year 2012. The highest number of contributions i.e. 186 (65.73 %) have been contributed by Single authors. The degree of collaboration ranges from 0.24 to 0.47 and the average degree of collaboration is 0.34. 283 journal articles published with a total page of 2385 (average 8.42 pages per article). Out of 8157 references, the highest number of citations 2007 (22.34 %) was in the year 2007. The maximum articles were contributed by authors from India (73.87 %), followed by United States (6.41 %), China (3.8 %) and United Kingdom (3.08 %). The highest number (First Rank) of articles were contributed by authors from New Delhi (21.22 %), followed by West Bengal (12.54 %) and Karnataka (11.89 %).

Das (2013) analyzed the journal "Library Trends" covering 206 articles published from 2007-2012 and found that highest number (51) of articles is published in 2007-08. Majority of authors preferred to publish their research results in individual authorship mode (122, 59.22%). The majority of articles 63 (30.58%) have the length of 16- 20 pages. The highest number of contributions have citations between 11 to 20 is 48 (23.30%).

Edeworr (2013) evaluated the 'Journal of Information and Knowledge Management (IJIKM)' over a four year period of 2010-2013 and revealed that journal is the most preferred source of citation in LIS research. Library Philosophy and Practice, an e-journal topped the list of journals most cited in IJIKM. Use of Internet resources is fast gaining ground amongst scholars and academics in Nigeria. Information technology was the most researched subject. There was clear absence of international collaboration among authors

published in the journal. Majority of the authors prefer multiple authorship against single authorship and are mainly from academic institutions especially the University.

Kavitha (2013) conducted a Bibliometrics study on 'Indian Journal of Nutrition and Dietetics' from 2007-2011 and found that majority of papers are multi authored. The degree of collaboration is found to be 0.95. Tamilnadu is the highest contributor in India. The highest number 64 (20.85%) articles out of total 307 have appeared in the year 2007 & 2009. Maximum number of articles (126, 41.05%) has been contributed by two authors. The degree of collaboration is 0.95. The journal is dominated by the host country (i.e. India).

Maharana and Das (2013) explored the publication trends of Malaysian Journal of Library and Information Science (MJLIS) 2007-2011. Padma and Ramasamy (2013) carried out a bibliometric study of the journal "Journal of Information Literacy" (2007-2012) - a free online journal. The study focused on the authorship pattern, types of publications, citation study, no. of pages, institution-wise output, country-wise output, the degree of collaborative research, degree of collaboration, year-wise and volume-wise contributions etc.

Pareek (2013) carried out a bibliometric study of the literature of the IFLA journal during 2001-2010. The study deals the distribution of article by year, authorship patterns, and distribution of contributions by institution, subject distributions, citation patterns, length of article, rank of cited authors, and geographical distributions of authors. Rabindra and Das (2013) analysed the publication trends of Malaysian Journal of Library and Information Science (MJLIS) to examine the year/ volume wise, country-wise distribution of contributions, authorship patterns, degree of collaboration, pattern of co-authorship, length of paper published, study of citation, most prolific contributor, country and institution/organization etc for the period 2007-2011.

Roy and Basak (2013) conducted a Bibliometric study on 'Journal of Documentation'. The study focused on authorship pattern, degree of collaboration, geographical distribution of papers and citation analysis. Watti and Tiwari (2013) evaluated the articles published in SRELS Journals of Information Management from 2006-2011 to find out the authorship pattern, Year wise distribution, length of article, degree of collaboration and geographical distribution of authors. Swain (2012) undertook a bibliometric study of 'Journal of Intellectual Property Rights' for the period 2002-2010. The study covers totally 332 articles carrying 1,541 journal citations.

Thanuskodi (2011) undertook a study on bibliometric analysis of the journal titled “Library Herald” for the period 2006 to 2010. The study covered variables like number of articles, authorship Pattern, subject wise distribution of articles, average number of references per articles, forms of documents cited year wise distribution of cited journals etc. Warraich and Ahmad (2011) evaluated 111 publications from 11 issues of the Pakistan Journal of Library & Information Science (PJLIS) during 1995 to 2010. Patil (2010) examined the articles published in “Herald of Library Science” from 1995-2005 and evaluate the distribution of articles, authorship pattern, degree of collaboration among the authors and geographical distribution of papers.

Thanuskodi (2010a) analysed the research output of ‘Journal of Social Science’ studying number of articles, authorship pattern, subject wise distribution of articles, average number of references per articles, forms of documents cited, year wise distribution of cited journals etc. Amudha, Baskaran and Lawrence (2009) evaluated the Indian Journal of Marketing from 2001-2005. Nandi and Bandyopadhyay (2008) conducted a bibliometric study on Indian Economic Review from 1998 to 2002. The study explored indicators like type of documents used by the authors of economics review, authorship pattern and geographical distribution of authors. Senthilkumaran and Vadivel (2003) undertook a Bibliometric study of the 'Spice India' journal for the period 1997 – 2001 to understand the various characteristics of lit like year-wise distribution of articles, authorship pattern, length of articles, year-wise distribution of citation, subject wise breakup of articles and leading authors.

IV. Objectives of the Study

The objectives set for the present study are :

- To reveal the year-wise and volume-wise distribution of articles in the journal of bioscience and bioengineering
- To find out the Relative Growth rate, Doubling time, Annual Growth Rate, Growth Ratio, Degree of Collaboration, Rate of Single Authorship, activity index, relative specialization index, collaborative Author Index and Science Production Index of the research output
- To know the page length of the articles
- To analyse the number of citations received by the articles in terms of year and volume
- To elicit the most prolific authors, h-index of authors,

- To draw out the year-wise authorship pattern of research output along with the size of research teams
- To identify the keywords used in the articles
- To shows the year-wise country-wise distribution of research output and citations received
- To know the most prolific collaborative research efforts of countries and individuals
- To find out the most cited references and articles along with the age of references
- To reveal the year-wise organization-wise distribution of research output and
- To forecast the future productivity of the journal

V. Hypotheses

- The research output of the journal follows linear growth model.
- There is no significance correlation between number of articles and number of pages
- There is no significant correlation between number of articles and number of citations received
- There is no significant correlation between number of authors and number of records

VI. Research Methodology

- Source : Web Of Science
- Scope : Journal of bioscience and bioengineering with 2835 articles (All are in English Language)
- Duration : 2007-2016
- Software used for Data analysis : Bibexcel and MS Excel
- Technique : Normal count procedure

VII. Data Analysis and Interpretation

7.1 YEAR METRICS

Table 1 : Year-wise publication of articles

Year	No. of Articles	%	Cum. Total	Cum. %
2007	188	6.63	188	6.63
2008	223	7.87	411	14.50
2009	709	25.01	1120	39.51
2010	241	8.50	1361	48.01
2011	246	8.68	1607	56.68

2012	261	9.21	1868	65.89
2013	250	8.82	2118	74.71
2014	250	8.82	2368	83.53
2015	238	8.40	2606	91.92
2016	229	8.08	2835	100
Total	2835	100		
Average Article Per Year = 2835/10			283.5	

Table 1 shows that year 2009 had seen a maximum of 709 (25.01%) articles in the Journal of Bioscience and Bioengineering. The remaining 75% of the articles were published in a span of 9 years. While 2012 has the second highest number of articles (261, 9.21%), the least number of 188 (6.6.3%) articles were published in 2007. On an average, 283 articles were published per year. The first four years contributed 48.01% (1361) of the research output while the next 6 years contributed the remaining 51.09% of the research output.

Table 2 : Volume-wise Distribution of Articles

Year	Volume No.	No of Articles	%
2007	103	95	3.35
	104	93	3.28
2008	105	116	4.09
	106	107	3.77
2009	107	121	4.27
	108	588	20.74
2010	109	114	4.02
	110	127	4.48
2011	111	130	4.59
	112	116	4.09
2012	113	138	4.87
	114	123	4.34
2013	115	123	4.34
	116	127	4.48
2014	117	126	4.44
	118	124	4.37
2015	119	120	4.23
	120	118	4.16
2016	121	111	3.92
	122	118	4.16
Total		2835	100.00
Average Articles per volume		141.75	

Table 2 shows that volume 108 published in 2009 is the most productive volume with 588 (20.74%) articles. All other volumes (19 in numbers) have published 3.28 % (93, vol.104) to

4.87% (138, Vol.113) of articles. First 10 volumes have contributed 56% of total output while the remaining 44% of the output was contributed by the last 10 volumes.

3 : Linear Vs Exponential Growth Pattern

It is inferred from Figure 1 and Figure 2 that the research output of the Journal of Bioscience and Bioengineering follows linear growth pattern ($r=0.046$) than the exponential growth pattern ($r=0.020$).

Linear Growth Pattern Vs. Exponential Growth Pattern

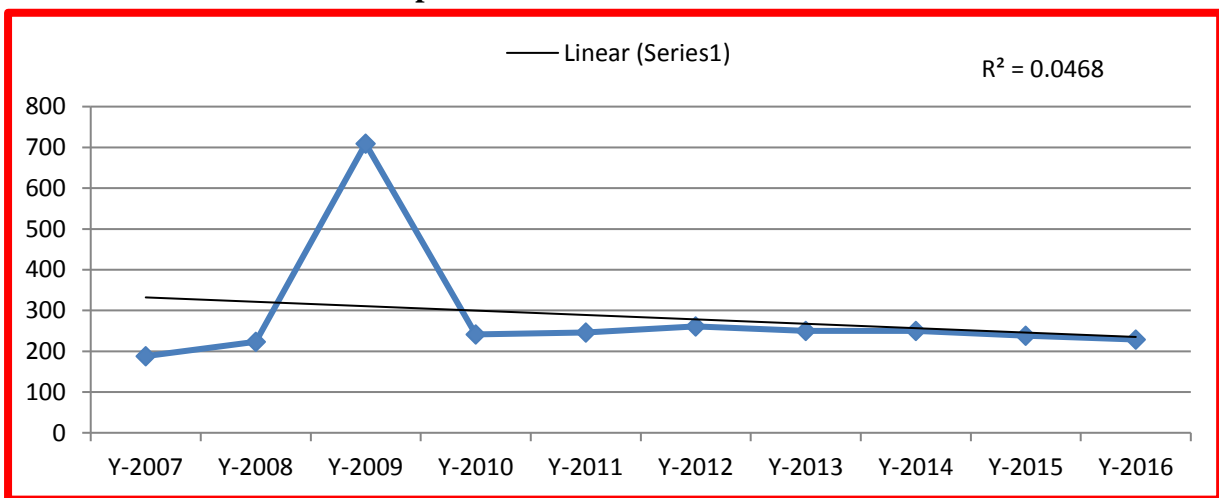


Figure 1 : Linear Growth of research Productivity of JBSBE

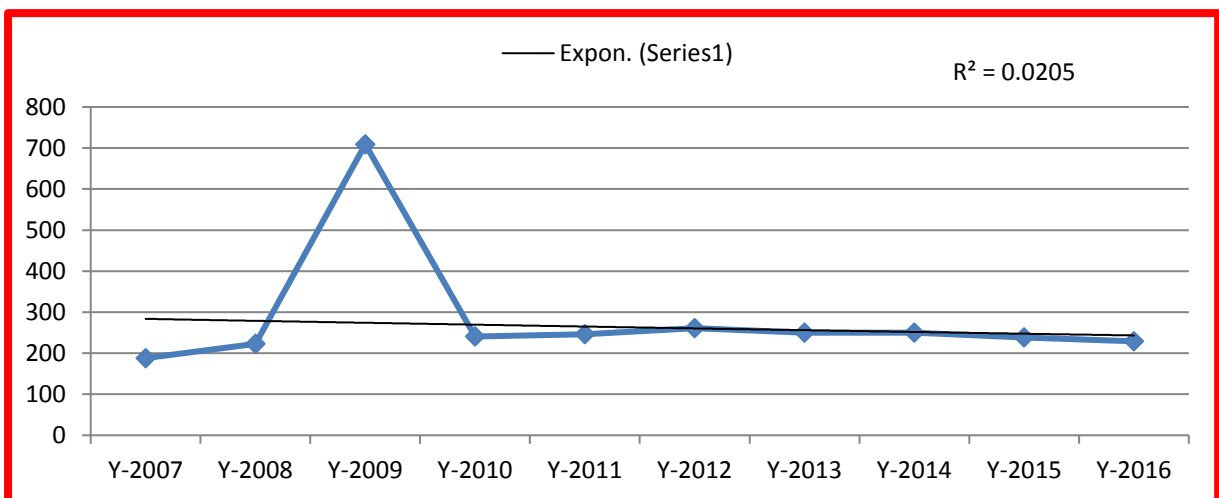


Figure 1 : Exponential Growth of research Productivity of JBSBE

Table 3 : Relative Growth Rate and Doubling Time

Year	No. of Records	Cumulative	log W1	log W2	RGR	Doubling Time
2007	188	188	0.00	5.24	5.24	0.13
2008	223	411	5.24	6.02	0.78	0.89
2009	709	1120	6.02	7.02	1.00	0.69
2010	241	1361	7.02	7.22	0.19	3.56
2011	246	1607	7.22	7.38	0.17	4.17
2012	261	1868	7.38	7.53	0.15	4.60
2013	250	2118	7.53	7.66	0.13	5.52
2014	250	2368	7.66	7.77	0.11	6.21
2015	238	2606	7.77	7.87	0.10	7.24
2016	229	2835	7.87	7.95	0.08	8.23

Table 3 reveals that RGR of the research output shows a decreasing trend. Though there is a slight increase in 2008 and 2009, the RGR decreased from 1.00 in 2009 to 0.15 in 2012, 0.11 in 2014 and 0.08 in 2016. The doubling time of the research output kept on increasing from 2009 onwards. From the mere 0.69 in 2009, it reached 4.60 in 2012 and 8.23 in 2016. Thus, the amount of time taken to double the literature gets increased year by year.

Table 4 : Annual Growth Rate

Year	No. of Records	AGR	AGR with base year 2011
2007	188	-	-0.23
2008	223	0.19	-0.09
2009	709	2.18	1.88
2010	241	-0.66	-0.02
2011	246	0.02	0
2012	261	0.06	0.06
2013	250	-0.04	0.01
2014	250	0.00	0.01
2015	238	-0.05	-0.03
2016	229	-0.04	-0.06

Table 4 shows that the annual growth rate of the research output shows oscillations. The highest AGR was witnessed in 2009 (2.18). There was a positive AGR in 5 years and negative growth rate in 4 years. The least AGR of -0.04 was seen in 2013 and 2016. The AGR was nil in 2014 as the research output of 2013 and 2014 are one and the same.

Table 5 : Year-wise Ratio of Growth

Year	No. of Records	ROG	ROG with base year 2011
2007	188	-----	0.76
2008	223	1 : 1.19	0.91
2009	709	1 : 3.18	2.88
2010	241	1 : 0.34	0.98
2011	246	1 : 1.02	1.00
2012	261	1 : 1.06	1.06
2013	250	1 : 0.96	1.02
2014	250	1 : 1.00	1.02
2015	238	1 : 0.95	0.97
2016	229	1 : 0.96	0.93

Table 5 discloses that during 2010, 2013, 2015 and 2016, the ratio of growth is less than 1 indicating that the quantum of articles published in the concerned years is less than that of the previous years. During 2008, 2009, 2011, 2012 and 2014 , the ratio of growth is more than 1 conveying that the number of articles published during those years is more than that of previous years.

Table 6 : Time Series Analysis

x	y	X	X ²	Xy
2007	188	-4.5	20.25	-846
2008	223	-3.5	12.25	-780.5
2009	709	-2.5	6.25	-1772.5
2010	241	-1.5	2.25	-361.5
2011	246	-0.5	0.25	-123
2012	261	0.5	0.25	130.5
2013	250	1.5	2.25	375
2014	250	2.5	6.25	625
2015	238	3.5	12.25	833
2016	229	4.5	20.25	1030.5
	2835	0	143	582
Year	Estimated Output			
2025	338.4441			
2030	358.7937			
2035	379.1434			
2040	399.493			

Table 6 shows the results of time-series analysis. It is estimated that there will be a progressive growth in the journal output in the years to come. The estimated output of the journal will be 338 in 2025, 358 in 2030, 379 in 2035 and 399 in 2040.

7.2 AUTHOR METRICS

Table 7 : Most Prolific Authors

Name of the author	No. of articles	% of 577	% of 2835
Kondo A	52	9.01	1.83
Tanaka T	51	8.84	1.80
Fukusaki E	46	7.97	1.62
Bamba T	40	6.93	1.41
Taya M	32	5.55	1.13
Kino-Oka M	31	5.37	1.09
Fujii T	27	4.68	0.95
Omasa T	26	4.51	0.92
Ogino C	26	4.51	0.92
Honda H	24	4.16	0.85
Shimizu H	24	4.16	0.85
Ito A	23	3.99	0.81
Kawabe Y	23	3.99	0.81
Ohtake H	23	3.99	0.81
Shimizu S	22	3.81	0.78
Kamihira M	22	3.81	0.78
Isobe K	22	3.81	0.78
Shimizu K	21	3.64	0.74
Sonomoto K	21	3.64	0.74
Takagi H	21	3.64	0.74

Table 7 shows that Kondo A is the most productive author with 52 (1.83%) articles in the journal followed by Tanaka T with 51 articles and Fukusaki E with 46 articles. There are 20 authors who have produced more than 20 articles. There are 14 authors with 21-27 articles and just two authors with 31-32 articles and 40-46 articles.

Table 8 : Authorship Pattern

Authorship Pattern	N of records	%	No of authors
1	56	1.98	56
2	234	8.25	468
3	443	15.63	1329
4	538	18.98	2152
5	501	17.67	2505

6	403	14.22	2418
7	290	10.23	2030
8	169	5.96	1352
9	89	3.14	801
10	52	1.83	520
11	33	1.16	363
12	12	0.42	144
13	4	0.14	52
14	5	0.18	70
15	4	0.14	60
16	1	0.04	16
22	1	0.04	22
Total	2835	100.00	14358
Average number of authors per article			5.06
Average number of articles per author			0.20

Table 8 shows that single authorship style is not popular in bioscience and bioengineering research. Only 56 (1.98%) articles were contributed in single author style. Even joint author style is not popular as it has contributed just 234 (8.25%) articles. The authors working in small research teams have contributed the most. The three author style with 443 (15.63%) articles, four author style with 538 (18.98%) articles, five author style with 501 (17.67%) articles and six author style with 403 (14.22%) ... have contributed 66.5% (1885) of total research output of the journal during 20076-2016. The average authors per article is 50.6 and the average articles per author is 0.20 with a total of 14358 authors. There is just one article with 22 authors and 16 authors each.

Table 9 : Correlation between No. of Authors and No. of Articles

Correlations			
		No of Authors	No of Records
No of Authors	Pearson Correlation	1	-.679**
	Sig. (2-tailed)		.003
	N	17	17
No of Articles	Pearson Correlation	-.679**	1
	Sig. (2-tailed)	.003	
	N	17	17

** . Correlation is significant at the 0.01 level (2-tailed).

To investigate if there was a statistically significant association between number of authors and number of articles, a correlation was computed. Table 9 shows that $r(17)=-.68$, $p = .003$. The direction of the correlation was negative, which means that the more number of authors

the less number of articles. The correlation is significant as the p-value is less than the significant level of 0.05. The null hypothesis is rejected.

Table 10 : Size of Research Team Vs. Number of Contributions

Research Team Size	No. of Authors involved	No. of Papers	%
Solo	1	56	1.98
Duet	2	234	8.25
Very small	3 – 4	981	34.60
Small	5 – 10	1504	53.05
Medium	11 – 20	59	2.08
Large	> 20	01	0.04
Total		2835	100

Table 10 shows that very small teams and small teams are active in bioscience and bioengineering research as they contributed 87.65% of total research output. Medium and large research teams have produced only a meagre amount of publications.

Table 11 : Year-wise Distribution of Authorship Pattern

No. of authors	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Grand Total
1	4	1	39	2	2	4	3			1	56
2	17	14	84	11	9	22	19	22	21	15	234
3	32	27	144	37	42	39	33	34	32	23	443
4	28	49	144	49	46	44	44	50	44	40	538
5	43	54	108	45	48	43	40	37	38	45	501
6	27	30	95	38	31	38	31	35	34	44	403
7	18	20	46	31	31	36	33	29	19	27	290
8	9	12	23	14	15	11	21	24	24	16	169
9	6	8	7	7	9	12	14	8	11	7	89
10	2	3	10	2	8	8	3	4	8	4	52
11	2	4	3	4	2	2	5	4	2	5	33
12		1	3	1	1	1		1	3	1	12
13			1		1		1		1		4
14			2			1	1			1	5
15					1		1	2			4
16							1				1
22									1		1
Grand Total	188	223	709	241	246	261	250	250	238	229	2835

Table 11 shows that a maximum of 39 single authored articles were published in 2009. There was not even a single article in 2014 and 2015 in solo authorship. The year 2009 had seen the maximum number of articles in joint author style, three author style, four author style, five, six, seven and eight author style . The year 2013 has seen articles of 13, 14, 15 and 16 authors each.

Table 12 : Degree of Collaboration and Rate of Single Authorship

Year	Total papers	No of single authored papers	No of multi authored papers	DC	Rate of single authorship
2007	188	4	184	97.87	2.13
2008	223	1	222	99.55	0.45
2009	709	39	670	94.50	5.50
2010	241	2	239	99.17	0.83
2011	246	2	244	99.19	0.81
2012	261	4	257	98.47	1.53
2013	250	3	247	98.80	1.20
2014	250	0	250	100.00	0.00
2015	238	0	238	100.00	0.00
2016	229	1	228	99.56	0.44
	2835	56	2779		
Overall degree of collaboration (Subramanian)					98.02
Overall rate of single authorship (Ramasamy & Padma)					1.98

Table 12 shows that the degree of collaboration is 100 during 2014 and 2015 where all the articles were published in collaborative fashion. During other years, the degree of collaboration varies from 94.50 in 2009 to 99.56 in 2016. The overall degree of collaboration for the study period is 98.02. This shows the dominance of collaborative research in bioscience and bioengineering areas. The overall rate of single authorship is just 1.98.

Table 13 : Collaborative Author Index (CAI)

Year	Single Author	CAI	Joint Author	CAI	Three Authors	CAI	Total
2007	4	107.71	17	109.55	32	108.93	188
2008	1	21.73	14	72.80	27	74.16	233
2009	39	278.47	84	143.54	144	129.98	709
2010	2	42.01	11	55.30	37	98.25	241
2011	2	41.16	9	44.32	42	109.26	246
2012	4	77.59	22	102.12	39	95.63	261

2013	3	60.75	19	92.08	33	84.47	250
2014	0	0.00	22	106.62	34	87.03	250
2015	0	0.00	21	106.90	32	86.04	238
2016	1	22.11	15	79.36	23	64.27	229
Total	56	100.00	234	100.00	443	100.00	2835

S. No.	Benchmark	Meaning
1.	CAI = 100	The number of publications corresponds to the average within a co-authorship pattern.
2.	CAI >100	The number of publications are higher than the average
3.	CAI <100	The number of publications are lower than the average

Table 13 shows that the CAI of single authored articles range from 21.73 in 2008 to 278.47 in 2009. Only in 2007 and 2009 the number of single authored publications is higher than the average. As far as joint authored articles are concerned, the CAI is more than 100 i.e. the number of publications is more than the average during 2007, 2009, 2012, 2014 and 2015 and it is less than average during all other years. It is the least in 2011 (44.32). Three authored articles have CAI ranging from 64.27 in 2016 to 129.98 in 2009.

Table 14 : H-Index of Authors

h-index	Author	Citation sum within h-core	All citations	All articles
14	Fukusaki E	441	582	46
12	Bamba T	343	455	40
10	Furukawa K	258	309	18
10	Sonomoto K	262	311	21
9	Honda H	197	252	24
9	Ito A	249	280	23
9	Matsumoto K	238	254	15
9	Kondo A	189	245	52
9	Taya M	111	177	32
9	Shimizu H	169	201	24
9	Shimoi H	188	220	17
9	Kobayashi A	198	207	16
9	Tanaka T	132	176	51
9	Kawakami K	222	245	14
9	Fujii T	206	250	27
8	Ohtake H	190	221	23
8	Ueda M	183	197	17
8	Shioya S	165	199	16

8	Sakai S	188	211	15
8	Fukuoka T	155	162	11
8	Sakai Y	117	139	20
8	Kino-oka M	98	156	31
8	Shimizu K	223	268	21
8	Kawabe Y	161	183	23
8	Ijima H	126	169	18
8	Katsuda T	101	102	11
8	Soda S	124	133	13
8	Ike M	155	180	17
8	Omasa T	132	160	26

Table 14 shows that Fukusaki E has the highest h-index of 14 for his 46 articles and 582 citations. He is followed by Bamba T with the h-index of 12 for his 40 articles and 455 citations. Four authors have 10 and plus h-index while 11 authors have the h-index of 9. 14 authors have the h-index of 8 i.e. 8 of their articles are cited at least 8 times.

Table 15 : Most prolific joint Authors

No of publications	Author 1	Author 2
35	Bamba T	Fukusaki E
26	Kondo A	Tanaka T
22	Kondo A	Ogino C
22	Kamihira M	Kawabe Y
22	Kino-oka M	Taya M
19	Ito A	Kawabe Y
18	Ito A	Kamihira M
18	Honda K	Ohtake H
17	Ohtake H	Omasa T
17	Harashima S	Sugiyama M
16	Honda K	Omasa T
16	Kim MH	Kino-oka M
15	Harashima S	Kaneko Y

Table 15 discloses that Bamba T and Fukusaki E are the most prolific joint authors who have contributed 35 articles followed by the pair – Kondo A and Tanaka T with 26 articles. Three pairs have contributed 22 articles each and two pairs have contributed 18, 17 and 16 articles each. Kondo A has published 22 articles with Tanaka T and 22 articles with Ogino C followed by Ito A who has published 19 articles with Kawabe Y and 18 articles with Kamihira M.

Table 16 : Year-wise distribution of Research productivity of Prolific Authors

Name of the author	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Grand Total
Kondo A	2	2	34	1	1	3	3	2	1	3	52
Tanaka T	1	3	26	4	1	3	5	2	2	4	51
Fukusaki E		8	3	2	3	9	4	7	2	8	46
Bamba T	1	5	3	2	4	9	2	6	2	6	40
Taya M	4	4	9	4	2	5	2	1	1		32
Kino-oka M	4	4	7	3	3	3	1	1	3	2	31
Fujii T	1	2	7	3	2	1	2	8		1	27
Ogino C	1		18		1	2	2	1		1	26
Omasa T		5	7	2	2	1	1	2	4	2	26
Honda H	4	5	6	5	3					1	24
Shimizu H	2	3	4	3	1	2	2		7		24
Ito A	5	2	7	1	2	2			4		23
Kawabe Y	2	3	8	1	2	3			4		23
Ohtake H		6	9	3	1	1	1	2			23
Isobe K	3	4	2	1		2	3	3	4		22
Kamihira M	1	3	8	1	2	3			4		22
Shimizu S		4	6	1	3	1	3	1	2	1	22
Shimizu K	2	2	6	3	2	1	4		1		21
Sonomoto K	3	2	3			2	3	2	4	2	21
Takagi H	2	1	2	1	1	4	2	2	6		21

Table 16 reveals that Kondo A who is the most prolific author with 52 articles has a maximum of 34 articles in 2009 and the minimum of 1 article in 2010, 2011 and 2015. He is followed by Tanaka T (51 articles) with a maximum of 26 articles in 2009 and one article in 2007 and 2011. There are four authors who have been publishing articles in the journal of bioscience and bioengineering from 2007 to 2016 without any break. Out of top 20 authors, 9 authors have not contributed any article in 2016 followed by 6 authors who have not contributed any article in 2014.

7.3 CITATION ANALYSIS

Table 17 : Number of Articles Vs No. of Citations received

No. of citations received	No. of articles	%	No. of citations received	No. of articles	%
0	716	25.26	35	5	0.18
1	280	9.88	38	5	0.18

2	242	8.54		39	4	0.14
3	179	6.31		37	4	0.14
4	154	5.43		46	3	0.11
6	119	4.20		51	3	0.11
5	117	4.13		43	3	0.11
8	109	3.84		53	2	0.07
7	98	3.46		63	2	0.07
9	85	3.00		55	2	0.07
11	72	2.54		60	2	0.07
10	70	2.47		86	2	0.07
12	54	1.90		73	2	0.07
15	53	1.87		47	2	0.07
13	45	1.59		48	2	0.07
16	40	1.41		45	2	0.07
14	34	1.20		50	2	0.07
18	32	1.13		44	2	0.07
17	31	1.09		99	1	0.04
20	26	0.92		66	1	0.04
23	23	0.81		70	1	0.04
21	18	0.63		83	1	0.04
22	18	0.63		81	1	0.04
19	17	0.60		74	1	0.04
26	16	0.56		78	1	0.04
25	15	0.53		65	1	0.04
32	12	0.42		42	1	0.04
24	12	0.42		49	1	0.04
29	11	0.39		52	1	0.04
28	9	0.32		141	1	0.04
30	9	0.32		193	1	0.04
27	8	0.28		119	1	0.04
33	8	0.28		609	1	0.04
34	8	0.28		62	1	0.04
40	7	0.25		64	1	0.04
36	7	0.25		54	1	0.04
41	6	0.21		56	1	0.04
31	6	0.21		57	1	0.04
Total					2835	100

Table 17 shows that one fourth of the articles (25.26 %, 176) of the articles did not receive any citation and 10% of the articles received just one citation. Only less number of articles received highest number of citations. There is an article with a maximum of 609 citations followed other two articles with 193 and 141 citations.

Table 18 : Correlation between No. of Articles and No. of citations received

Correlations			
		No of Articles	No of Citations Received
No of Articles	Pearson Correlation	1	-.226
	Sig. (2-tailed)		.050
	N	76	76
No of Citations Received	Pearson Correlation	-.226	1
	Sig. (2-tailed)	.050	
	N	76	76

To investigate if there was a statistically significant association between number of articles and number of citations received, a correlation was computed. Table 18 shows that $r(76) = -.23$, $p = .050$. The direction of the correlation was negative, which means that the less number of articles the more number of citations. The correlation is not significant as the p-value is equal to the significant level of 0.05. The null hypothesis is accepted.

Table 19 : Year-wise Distribution of Citation received

No of citations received	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Grand Total
0	4	9	43 1	7	9	16	16	33	43	14 8	716
1	4	11	59	6	14	24	23	40	59	40	280
2	6	8	23	17	19	20	33	39	49	28	242
3	4	8	16	24	15	13	31	32	27	9	179
4	12	10	13	16	18	24	19	20	18	4	154
5	6	13	6	14	13	19	22	14	10		117
6	11	13	9	12	14	16	15	16	13		119
7	5	8	19	13	13	14	11	10	5		98
8	10	13	13	14	13	19	16	7	4		109
9	7	11	11	13	10	11	12	8	2		85
10	5	6	10	8	12	13	10	5	1		70
11	6	11	8	5	11	14	4	10	3		72
12	7	4	6	10	9	8	6	3	1		54
13	3	4	7	7	6	9	6	2	1		45
14	5	8	7	4	2	3	3	1	1		34
15	13	10	6	7	5	2	6	4			53
16	8	4	6	5	8	6	2	1			40
17	5	5	4	6	6	3	1	1			31

66	1											1
70		1										1
73	2											2
74	1											1
78			1									1
81	1											1
83		1										1
86		2										2
99				1								1
119		1										1
141				1								1
193	1											1
609	1											1
Grand Total	188	223	709	241	246	261	250	250	238	229		2835

Table 19 shows the year-wise distribution of citations received for the articles. The natural phenomena which is proved here too is that the articles published in the earlier years i.e. 2006-2010 have received more citations than the articles published in 2013-2016. The articles which have received 193 and 609 citations respectively were published in 2006. The maximum number of citations received by an article published in 2016 is just 4.

Table 20 : Country-wise Citations received

No of citations received	Australia	Germany	India	Indonesia	Japan	Malaysia	Peoples R China	Singapore	South Korea	Taiwan	Thailand	Turkey	UK	USA
0	7	6	14	10	393	10	79	4	140	37	12	2	1	20
1		5	5		193	3	38		18	5	7	3	4	10
2	2	3	6	1	161	2	29	2	18	8	2	4	3	9
3	1	4	2	1	125	2	18	1	14	10	2			3
4		3	8		98	4	18	1	9	5	6	4	1	3
5		1	5	2	78	1	19		5	3	5		1	1
6		2	4		84		11	1	4	12	1			2
7			2	1	70	1	10		3	1	4			3
8		2	2	3	80		14		6	2				3
9		1	1		55	2	12		8	6		1	2	1
10		1	3	1	43	1	11		2	1	3	1		
11			2	1	48	1	12	1	7	3	3	1		1
12		1	5		35		5	1	5	3	3			1

13	1	1			31		4		1	2	2			2
14			1		30	1	4		1				1	
15			3		33		8	1	5	2				3
16	1	1	3		22	2	3		5	3	2		2	2
17					17		2		7	2	1		1	1
18			4		19		2		2	2	1			2
19			3		8		3	1	1	1				
20		2			18		3		1	1	1			1
21			2		9		5			1				1
22		1			12		1		1	2				2
23	1		2		9		5		1	1	2			1
24		1			10		2							
25					7		5		1			1		
26					8		4		1	1	3			
27			1		3		1		3	1				
28					5	1	1		1					
29	1		1		6		1		3	1				1
30			2		5		1		1		1			
31					3		1		1					1
32	1				6		2		1					
33					5		3				1			
34					4		2			1	1			
35					5	1								
36					5	1			2				1	
37					2		1							
38					3				1					
39					4									
40					3		2		2					1
41					6		1				2			
42					1									
43					1			1				1		1
44						1			1		1			
45					1									
46					1						1			2
47					1						1			
48					1				1					
49											1			
50					1		1							1
51					2						1			
52					1									1
53					2									
54							1							
55					2									
56	1				1		1							
57										1				

60					1			1						
62					1									
63					1				1					
64					1									1
65					1									
66					1									
70					1									
73					2									
74					1									
78					1									
81					1								1	
83									1					
86					1									
99														1
119					1									
141											1			
193					1									
609					1									
Grand Total	16	35	81	20	1792	34	346	15	285	118	71	18	18	82

Table 20 shows that out of 1792 articles published by Japan, 393 articles did not receive any citation. While 193 articles received just 1 citation, 161 articles received 2 citations. The articles which had received 193 and 609 citations are contributed by Japan.

Out of 346 articles published by China, 79 articles did not receive any citation and 38 of them received just 1 citation.

The articles published by countries like Australia, Germany, India, Indonesia, Malaysia, China, Turkey and Taiwan have not received 60 or more than 60 citations. There is an article from Thailand which has received 141 citations. USA has contributed an article which has received 99 citations.

As far as India is concerned, 14 did not get any citation, 5 articles received 1 citation, 6 articles received 2 citations and 2 articles received 3 citations. A maximum of 30 citations were there for 2 articles.

Table 21 : Most prolific cited references

Cited reference	No of times cited in the references
Laemmli UK, 1970, V227, P680, Nature, Doi 10.1038/227680A0	123
Bradford MM, 1976, V72, P248, Anal Biochem, Doi 10.1006/Abio.1976.9999	115

Lowry OH, 1951, V193, P265, J Biol Chem	51
Miller GL, 1959, V31, P426, Anal Chem, Doi 10.1021/Ac60147A030	47
Thompson JD, 1994, V22, P4673, Nucleic Acids Res, Doi 10.1093/Nar/22.22.4673	44
Sambrook J., 1989, Mol Cloning Lab Manu	43
Sambrook J, 2001, Mol Cloning Lab Manu	40
Saitou N, 1987, V4, P406, Mol Biol Evol	38
Muyzer G, 1993, V59, P695, Appl Environ Microb	34
Sambrook J., 2001, Mol Cloning Lab Manu	30
Tamura K, 2007, V24, P1596, Mol Biol Evol, Doi 10.1093/Molbev/Msm092	27
Dubois M, 1956, V28, P350, Anal Chem, Doi 10.1021/Ac60111A017	27
Altschul SF, 1990, V215, P403, J Mol Biol, Doi 10.1006/Jmbi.1990.9999	26
Bligh EG, 1959, V37, P911, Can J Biochem Phys	24
Murashige T, 1962, V15, P473, Physiol Plantarum, Doi 10.1111/J.1399-3054.1962.Tb08052.X	23
Altschul SF, 1997, V25, P3389, Nucleic Acids Res, Doi 10.1093/Nar/25.17.3389	21

Table 21 shows that article of Laemmli, UK published in 1970 in Nature was included in the list of references of 123 articles followed by the article by Bradford M M published in 1976 was cited in 115 articles. The article of Lowry O H published in 1951 was cited in 51 articles. 16 references were cited in more than 20 articles.

Table 22 : Year of Cited references Vs No of times cited (Age of References)

No of times cited	Year of cited references
4073	2006
4038	2005
3993	2007
3758	2008
3627	2004
3335	2009
3135	2002
3111	2003
2919	2010
2846	2001
2638	2000
2570	2011
2300	1999
2268	1998
2212	2012
1869	1997

1584	1996
1511	1995
1462	2013
1309	1994
1123	1993
1018	1992

Table 22 shows that references published in 2006 were cited the most by the researchers in bioscience and bioengineering during the study period. 2006 references were cited 4073 times. It is followed by 2005 references which were cited 4038 times and 2007 references which were cited by 3993 times. Thus, the authors have cited mostly the references published in 2005-2008. The sources published in 1992-1993 were least cited by the researchers. The sources of 2012 and 2013 were also least cited. The sources published in 2009 (3335 times), 2002 (3135 times), 2003 (3111) are also cited to a greater extent.

Table 23 : Most productive Articles

Title of the paper	No of times cited
Development of series of gateway binary vectors, pGWBs, for realizing efficient construction of fusion genes for plant transformation	609
Methods for inducing embryoid body formation: In vitro differentiation system of embryonic stem cells	193
Current trends in biodegradable polyhydroxyalkanoates	141
Recent Developments in Microbial Fuel Cell Technologies for Sustainable Bioenergy	119
Visualizing "green oil" in live algal cells	99
Microbial degradation of polychlorinated biphenyls: Biochemical and molecular features	86
Stoichiometric modelling of cell metabolism	86
Effect of ascorbic acid on bone marrow-derived mesenchymal stem cell proliferation and differentiation	83
Neurite outgrowths of neurons with neurotrophin-coated carbon nanotubes	81
Lantibiotics: Diverse activities and unique modes of action	78
High nitrogen removal performance at moderately low temperature utilizing anaerobic ammonium oxidation reactions	74
Synthesis of enzymatically-gellable carboxymethylcellulose for biomedical applications	73
Detergent alkaline proteases: Enzymatic properties, genes, and crystal structures	73
Biofilm Formation by Lactic Acid Bacteria and Resistance to Environmental Stress	70
Microbial manganese oxide formation and interaction with toxic metal ions	66
Recent development of anaerobic digestion processes for energy recovery from	65

wastes	
Improvement of isopropanol production by metabolically engineered <i>Escherichia coli</i> using gas stripping	64
Aerobic Denitrification of <i>Pseudomonas putida</i> AD-21 at Different C/N Ratios	63
Effective cell-seeding technique using magnetite nanoparticles and magnetic force onto decellularized blood vessels for vascular tissue engineering	63
Methanogenic pathway and community structure in a thermophilic anaerobic digestion process of organic solid waste	62
Electrospun conducting polymer nanofibers and electrical stimulation of nerve stem cells	60
Bioethanol production from xylose by recombinant <i>Saccharomyces cerevisiae</i> expressing xylose reductase, NADP(+)-dependent xylitol dehydrogenase, and xylulokinase	60

Table 23 shows that 22 articles have received 60 and more than 60 citations. While 8 articles received 60-66 citations, 5 articles received 70-78 citations. 4 articles received 81-86 citations. The article ‘Development of series of gateway binary vectors, pGWBs, for realizing efficient construction of fusion genes for plant transformation’ had received maximum of 609 citations.

Table 24 : Volume-wise Distribution of citations received

No of citations received	Volume number																				Total
	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	
0	2	2	6	3	4	4 2 7	1	6	3	6	7	9	5	1 1	1 5	1 8	2 0	2 3	5 6	9 2	71 6
1	2	2	3	8	3	5 6	1	5	4	1 0	1 2	1 2	1 2	1 1	1 7	2 3	2 2	3 7	2 2	1 8	28 0
2	3	3	3	5	7	1 6	8	9	1 1	8	9	1 1	1 6	1 7	2 2	1 7	2 4	2 5	2 1	7	24 2
3	1	3	3	5	7	9	1 4	1 0	9	6	5	8	1 4	1 7	1 5	1 7	1 2	1 5	8	1	17 9
4	6	6	6	4	6	7	8	8	7	1 1	9	1 5	1 1	8	8	1 2	1 2	6	4		15 4
5	3	3	8	5	4	2	1 2	2	9	4	1 3	6	8	1 4	7	7	6	4			11 7
6	8	3	7	6	3	6	3	9	5	9	9	7	6	9	9	7	9	4			11 9
7	2	3	4	4	1 0	9	3	1 0	7	6	1 1	3	5	6	4	6	3	2			98
8	3	7	7	6	8	5	8	6	8	5	6	1 3	1 0	6	2	5	3	1			10 9

52		1																		1
53		1									1									2
54				1																1
55			1			1														2
56															1					1
57					1															1
60			1							1										2
62										1										1
63	1			1																2
64									1											1
65	1																			1
66		1																		1
70				1																1
73	1	1																		2
74	1																			1
78					1															1
81	1																			1
83			1																	1
86			2																	2
99								1												1
119				1																1
141									1											1
193	1																			1
609		1																		1
Grand Total	95	93	16	17	11	58	14	17	10	16	13	23	23	22	26	40	18	11	18	2835

Table 24 shows that out of 716 articles which have not received any citation, 427 are from Vol.108 and 92 are from vol.122. The number of articles which have not received even a single citation goes on increasing from vol.115 to prove that the recent articles will be cited more in future. The article which received 609 citations is from Vol.No104 and the article with 193 citations is from Vol. No 103. The articles which have receive 60 and more citations are the ones published between Vol.No 103 and 112.

Table 25: Average Citations Per Volume and Article

Year	Volume No.	No of citations received	No. of Articles	Average Citation Per Article
2007	103	1892	95	19.92
	104	2193	93	23.58
2008	105	1896	116	16.34
	106	1645	107	15.37

2009	107	1666	121	13.77
	108	1312	588	2.23
2010	109	1436	114	12.60
	110	1544	127	12.16
2011	111	1514	130	11.65
	112	1142	116	9.84
2012	113	1209	138	8.76
	114	945	123	7.68
2013	115	881	123	7.16
	116	760	127	5.98
2014	117	602	126	4.78
	118	490	124	3.95
2015	119	396	120	3.30
	120	233	118	1.97
2016	121	104	111	0.94
	122	35	118	0.30
Total		21895		
Average citations per volume			21895/20= 1094.8	
Average Citations per article			21895/2835=7.72	

Table 25 shows that a total of 21895 citations were received by 2835 articles published in the Journal of Bioscience and Bioengineering during 2007-2016. The average citations per volume is 1095 and the average citations per article is 8 for the whole research output. The average citations per volume is the highest (23.58) for Vol. No. 104 followed by Vol. No. 103 with the average citation of 19.92 and Vol. No. 105 with the average citation of 16.34. Volume No. 122 has the average citations of just 0.30 followed by Vol. No. 121 with the average citations of 0.94.

7.4 SPATIAL METRICS

Table 26 : Country-wise Distribution : Science Production Index (SPI)

Name of the country	No. of records	SPI (% of 2835)
Japan	1792	63.21
Peoples R China	346	12.20
South Korea	285	10.05
Taiwan	118	4.16
USA	82	2.89
India	81	2.86
Thailand	71	2.50
Germany	35	1.23

Malaysia	34	1.20
Indonesia	20	0.71
UK	18	0.63
Turkey	18	0.63
Australia	16	0.56
Singapore	15	0.53
Iran	14	0.49
Spain	14	0.49
Canada	12	0.42
Italy	12	0.42
France	11	0.39
Mexico	10	0.35
Vietnam	10	0.35

Table 26 shows that Japan has emerged as the most productive country with the SPI of 63.21 (1792 articles). It is followed by China with 346 articles (SPI of 12.20) and South Korea with 285 articles (SPI of 10.05). While Taiwan is in the fourth place with 118 articles (SPI of 4.16), USA and India are in the fifth and sixth places with 82 (SPI of 2.89) and 81(SPI of 2.86) articles respectively. There are 21 countries which have contributed 10 and above articles. We could see a clear domination of Asian countries.

Table 27 : Year-wise Country-wise Distribution of Research Output

Country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Grand Total
Japan	138	170	395	164	156	176	170	148	149	126	1792
Peoples R China	16	23	66	22	26	26	29	43	40	55	346
South Korea	8	13	158	18	16	11	15	13	17	16	285
Taiwan	5	4	37	7	12	11	13	15	7	7	118
USA	9	3	12	9	7	9	8	5	10	10	82
India	4	6	3	5	9	9	12	12	8	13	81
Thailand	6	6	19	8	7	6	4	3	5	7	71
Germany		1	8	5	3	4	1	6	3	4	35
Malaysia		1	6	3	4	4	2	5	4	5	34
Indonesia		1	8	1	3	1	1	1	3	1	20
Turkey	1		1	1	2	4	1	1	4	3	18
UK	2	3	1	2	5	1	2			2	18
Australia	1		8	2		1	1	2		1	16
Singapore	1		2	1	3		2	4	1	1	15
Iran	1	1	3	2	1	1	1	2	1	1	14

Spain		2	2	1	1	2	1	2	2	1	14
Canada	1	1	2	1	3	1		2		1	12
Italy	1	2	1	2	1	3	2				12
France	1	2	1		1	1	3	1		1	11
Mexico		1	1	1	2	2		2	1		10
Vietnam			2			1	3	2		2	10

Table 27 shows that the most productive country – Japan – has contributed the least number of 126 articles in 2016 and the highest number of 395 articles in 2009. While China has contributed just 16 articles in 16, it reached its zenith in 2009 with 66 articles. A maximum of 12 articles were contributed by India in 2013 and 2014 and the least number of 3 articles in 2009. The contribution of European and American continents are the least except in the case of USA and UK.

Table 28 : Year-wise Activity index of Select Countries

country	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Japan	116.13	507.05	88.14	107.66	100.32	106.68	107.58	93.66	99.04	87.05
Peoples R China	69.73	71.37	76.27	74.80	86.60	81.62	95.05	140.93	137.71	196.79
South Korea	42.33	86.19	221.68	74.30	64.70	41.92	59.68	51.73	71.05	69.50
Taiwan	63.90	77.52	125.38	69.78	117.20	101.26	124.93	144.15	70.66	73.44
USA	165.51	141.26	58.52	129.11	98.38	119.22	110.63	69.15	145.27	150.97
India	74.47	71.62	14.81	72.61	128.05	120.69	168.00	168.00	117.65	198.69
Thailand	127.43	217.94	107.00	132.55	113.62	91.79	63.89	47.92	83.89	122.06

S.No	Benchmark	Meaning
1.	AI < 100	National level average efforts are lesser than world average
2.	AI = 100	National level average efforts = World level average efforts
3.	AI > 100	National level average efforts are more than world average

Table 28 shows that Activity Index of Japan is more than 100 in 2007, 2008, 2010, 2011, 2012 and 2013. AI is less than 100 during other years. But the AI of China is less than 100 during the first 7 years and more than 100 during 2014-2016. The AI of South Korea is less than 100 during the whole study period. As far as India is concerned, during the first four years of the study, the AI is less than 100 i.e. India's national efforts are less than the world average efforts. But, India's AI has crossed 100 in all the later years i.e from 2011-2016 indicating that her national average efforts are more than the world level average efforts.

Table 29 : Overall Activity Index and Relative Specialization Index (RSI)

Country	Total	Overall AI	Relative Specialization index
Japan	1413.30	141.3302	0.986
Peoples R China	1030.87	103.0872	0.981
South Korea	783.08	78.30775	0.975
Taiwan	968.22	96.82203	0.980
USA	1188.01	118.801	0.983
India	1134.59	113.459	0.983
Thailand	1108.08	110.808	0.982

Table 29 shows that the overall Activity Index of Japan, China, USA, India and Thailand have more than 100 while overall AI of South Korea and Taiwan is less than 100. The RSI of all the select countries is more than 0.97.

Table 30 : Collaborative Research

No. of Articles	Country 1	Country 2
47	Japan	Peoples R China
34	Japan	Thailand
21	Japan	USA
15	Peoples R China	USA
11	India	South Korea
10	Japan	South Korea
8	Indonesia	Japan
8	Germany	Japan
7	South Korea	USA
7	Peoples R China	Taiwan
7	Japan	Malaysia
6	Pakistan	UK
6	Japan	Taiwan
5	Japan	UK
5	Bangladesh	Japan
5	Australia	Peoples R China

Table 30 shows that Japan has emerged as the country with the best collaborative research effort. Being the host country of the journal, Japan has collaborate with all the leading countries in producing desired research output in bioscience and bioengineering. Japan and china have collectively published 47 articles followed by Japan and Thailand with 34 articles.

Table 31 : Year-wise Organization-wise Distribution of Research Output

Organization	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Grand Total
Osaka University	14	40	53	22	24	31	23	19	27	23	276
Kyushu University	14	16	16	8	10	10	10	7	15	11	117
University of Tokyo	9	2	30	9	13	12	21	6	10	3	115
Kobe University	7	7	47	3	5	8	9	5	7	3	101
Natl Inst Adv Ind Sci & Technology	8	8	21	13	5	8	10	12	7	9	101
Nagoya University	8	8	12	11	5	7	5	6	9	12	83
Kyoto University	8	11	15	2	3	5	14	8	6	3	75
Hokkaido University	8	8	8	9	7	8	9	7	4	5	73
Hiroshima University	8	6	13	6	6	3	6	7	1	7	63
Tohoku University	3	1	8	6	5	11	4	8	4	4	54
University of Tsukuba	5	3	17	9	3	4	3	5	4	1	54

Table 31 shows that Osaka University is the most productive organization with 276 articles followed by Kyushu University with 117 articles and University of Tokyo with 115 articles. Five organizations have contributed more than 100 articles each in the journal while 6 organizations have contributed 54-83 articles. A maximum of 53 articles in 2009 and the least of 14 in 2007 were contributed by Osaka University. Kyushu University which has contributed 16 articles in 2008 and 2009, has given just 7 articles in 2014. University of Tokyo has contributed a maximum of 30 articles in 2009 and the least of 2 in 2008.

7.5 OTHER METRICS

Table 32 : Page Length of the Articles

No. of pages	No. of articles	%
6	598	21.09
7	413	14.57
5	410	14.46
1	371	13.09
4	341	12.03
8	226	7.97
3	183	6.46
2	145	5.11
9	81	2.86
10	38	1.34
11	19	0.67
12	6	0.21
13	3	0.11

17	1	0.04
Total	2835	100

Table 32 shows that a majority of 21.09% (598) of the articles have 6 pages. It is understood that 5-7 pages length is the optimal size for the research articles (50% of the articles). The articles with 10 or more pages constitute the least.

Table 33 : Correlation between No. of Pages and No. of Articles

Correlations			
		No of Pages	No. of Articles
No of Pages	Pearson Correlation	1	-.647*
	Sig. (2-tailed)		.012
	N	14	14
No. of Articles	Pearson Correlation	-.647*	1
	Sig. (2-tailed)	.012	
	N	14	14

*. Correlation is significant at the 0.05 level (2-tailed).

To investigate if there was a statistically significant association between number of articles and number of pages, a correlation was computed. Table 33 shows that $r(14) = -.65$, $p = .012$. The direction of the correlation was negative, which means that the more number of pages the less number of articles. The correlation is significant as the p-value is less than the significant level of 0.05. The null hypothesis is rejected.

Table 34 : Keywords Used

Keyword Used	No. of records	%
Expression	255	8.99
Purification	204	7.20
Escherichia-Coli	180	6.35
Growth	134	4.73
Identification	127	4.48
Saccharomyces-Cerevisiae	118	4.16
Fermentation	115	4.06
In-Vitro	112	3.95
Gene	110	3.88
Protein	104	3.67
Cells	98	3.46
Culture	95	3.35
Bacteria	91	3.21

System	84	2.96
Yeast	83	2.93
Acid	82	2.89
Cloning	81	2.86
Degradation	80	2.82
Biosynthesis	79	2.79
Proteins	65	2.29
Differentiation	61	2.15
Enzyme	60	2.12
Metabolism	59	2.08
Strains	56	1.98
Gene-Expression	55	1.94
Binding	52	1.83
Genes	50	1.76

Table 34 shows that the keyword ‘ Expression’ is used in a majority of 255 (8.99%) articles followed by the keyword ‘Purification’ that appears in 204 (7.20%) articles and ‘ Escherichia-Coli’ that appears in 180 (6.35%) articles. 10 keywords appear in 100 plus articles and 17 keywords appear in 50-98 articles.

VIII. Findings

On an average, 284 articles were published in the journal every year. Two volumes are published every year. The research output from the Journal of Bioscience and Bioengineering for the period 2007-2016 amount to 2835 articles and the research output follow liner style of growth.

The Relative Growth Rate and the Doubling Time are in inversely proportional to each other. When RGR increases, the DT decreases. The annual growth rate shows oscillations. The analysis of time series calculations shows that there will be a progressive growth in future research output.

Kondo A is the most productive author with 52 articles. Most of the productive authors are from Japan, the host country of the journal.

As seen in most of the journals, the dominance of multi-authorship style is evident here too. The number of articles published by more than two authors is more than both solo and joint authored publications. The degree of collaboration is very high. The research output of small teams is high and commendable. The researchers in the field of bioscience and bioengineering prefer to work in small teams – say 3-10.

The Pearson Correlation test proves that there is a significant association between number of authors and number of articles published.

Fukusaki E has 582 citations for his 46 articles with the h-index of 14. His 14 of articles are cited atleast 14 times each. These 14 articles had received 441 citations. Bamba T and Fukusaki E have jointly contributed 35 articles.

Japan has contributed 1792 articles out of 2835. The contributions of Asian countries are more than that of other countries. India is in the sixth place with 81 articles. We could witness that the national level average research efforts of Japan compared to the global average research efforts is getting reduced over the years but it is getting increased over the years for Indian publications. Japan has collaborated with more number of countries to product a lion's share in the total research output.

Only less number of articles have received more number of citations. It is surprising to note that 25% of the articles have not received even a single citation. Japan has received more citations than by any other country. A good number of references cited in the articles were published between 2004 and 2009. The average number of citations per volume is 1095 and that of an article is 8.

Out of the top 10 institutions active, 9 are the universities and just one is a national level institute. Thus, universities play a major role in promoting research in bioscience and bioengineering.

IX : Suggestions

- ❖ Authors may be encouraged to form small research groups in every institution / area/ city / inter-city / inter-institution spaces to collaborate in producing research output.
- ❖ Special funds may be provided for the projects to be undertaken by small research teams apart from individual research projects.
- ❖ More research scholars and students may be motivated to write journal articles.
- ❖ The senior LIS professionals may help the budding students / research scholars in writing quality articles.
- ❖ The University may give some incentives for the students who publish articles with good impact factor.
- ❖ The authors from India may collaborate with the authors of other countries to produce productive articles.
- ❖ Inter-county collaborative research work may be boosted up to promote publications.
- ❖ The most productive institutions may be motivated further either in terms of money or in terms of congenial working atmosphere or in terms of availability of ICT infrastructure to further their research prospects.
- ❖ Separate chairs may be established in the most productive universities / institutes to promote research programmes in bioscience and bioengineering.

- ❖ The authors may be instructed to include sufficient number of key words in their research articles.
- ❖ The authors should be encouraged to use both print and web references equally well.
- ❖ As the researchers mostly cite the literature of recent past, the librarian in the periodical section and back-volume section should see that the recent volumes or sources of information are placed at accessible points in the library.
- ❖ The journal authorities may adopt the most prolific or most dominant authors to become a part of editorial process so as to encourage and honour them.
- ❖ The journal authorities should bring out certain standards in terms of length of papers, need for keywords, number of tables / graphs / charts, layout, referencing style, margin, line spacing, presentation modality etc so as to bring out certain uniformity in the presentation of articles.

X : Conclusion

The scientometric study on the ‘Journal of Bioscience and Bioengineering’ has brought out a lot of findings which will help the individual researchers, academia, library professionals, research organizations and the Govt. departments to take suitable actions to improve research activities and effective collaborative research spaces. The study reveals about the most productive authors, countries and institutions which are actively involved in bioscience and bioengineering research. It also talks about the qualitative aspects of the journal in terms of number of citations received by the articles published therein. It reveals on the countries and individual researchers who are collaboratively researching on bioscience and bioengineering. It may help the LIS professionals to build a local vocabulary controlled device using the keywords provided for in the research output.

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