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Scientometric Profile of Biochemistry Research in India: A Study Based on Web of Science

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ABSTRACT

The paper examines 25,132 biochemistry research contributions of Indian scientists covered in the Web of Science for a period of 10 years (2004-2013). It was found that the biochemistry research is gradually growing and average annual growth rate was 36.84 per cent. The solo research was not prevalent and team research is more in the Indian biochemistry research and 97.46 per cent publications were contributed by multi- authors. It was observed that the value of co- authorship index was generally increasing and it varied from 93 to 105 during the period of study. Journal articles contribute 89.43 per cent of the total output followed by reviews (7.14 %). Indian researchers collaborate largely with the researchers of USA (2.49 %). The geographical distribution shows that Tamil Nadu, Uttar Pradesh and Delhi lead the list. The study shows that, C. Abdul Jaleel (58) and L. Pai (37) are the top ranked authors in the field. '*Plos One*' is the top ranked journal and it published 296 papers during the study period. Academic institutions contribute more number of papers (50.26 %) followed by research institutions (28.24 %). The Lotka's law was not found fit with the observed author productivity distribution of Indian biochemistry research.

Keywords: Biochemistry; Authorship pattern; Research productivity; Degree of collaboration; Co-authorship index.

1. INTRODUCTION

The biochemistry discipline occupies a prominent stage in the current biological research and it is placed between science and medicine developed rapidly in the early 20th century. According to Ramasarma[1] "biochemistry in broad terms is the study of the chemical composition of the living matter and the biochemical processes that underlie life activities during growth and maintenance. It is one of the academic disciplines in life science that studies the structure, function metabolism and the mechanism of the components in the cells: such as proteins, carbohydrates, lipids, nucleic acids and vitamins up to the molecular level. There has been a lot of research on the subject of biochemistry and after due deliberations, their definitions have been set as to what is biochemistry". Biochemistry, soul of life sciences, has a versatile scope in the field of agriculture, pharmaceutical, nutritional, and medical sciences. It is the study of chemical compounds and processes that occur in or are caused by living organisms. It encompasses all aspects of biology, from molecules to cells, organisms, medicine, and toxicology.

The evaluation of research performance of a country, a region, research and academic institutions, discipline etc can be effectively done with scientometric techniques. Scientometrics presents a unique set of techniques for the monitoring, evaluation and analysis of information resources and for the management of knowledge. These studies are being conducted to assess the quantitative and qualitative development of different subjects and disciplines, especially in sciences. The biochemistry research and development have brought out several studies. Hence, to assess the quantitative developments in the field of biochemistry research using scientometric methods are useful to the stakeholders of this field of knowledge. The present study investigates various characteristics of research productivity in biochemistry from India covered in the web of science.

Plenty of scientometric studies are available on Indian contributions in different subject fields. But very few studies have been conducted on Indian biochemistry research in the past. Chauhan[2] has made a study on drone research at the global level, to quantify the research output based on scopus database for a period of 1968- 2017. Various bibliometric techniques were used to find out the growth rate of publications (annually 16.00 percent), citation analysis (cited rate 58.33 percent), authorship pattern and most productive countries were studied using various bibliometric methods. Malik, Aftab, and Ali[3] presented a bibliometric examination of the crowd sourcing publications by using web of science for a period between 2008 and 2017. It was identified that 81 per cent of the total publications were articles and *PLOS One* was identified as the top journal in terms of total output and total citations. Varma and Shukla[4] analysed the growth of literature on information literacy (2008-2017) and found that a total of 9496 research

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papers were published in the area. The study examined the different scientometric parameters and found that the maximum 1234 (12.99 %) were published in 2016 and the annual growth rate was recorded in 2010 (25.68 %). Roy[5] performed a study on India's scientific productions in biological science (1901-1947) by using scientometric techniques. It was found that, during 1901-1947 the duplication time and the mean relative growth rate is 1.007 and 0.615 respectively. The Lotka's law of author productivity follows the biological science research data and the women researcher's productivity contributed 0.62 per cent publications.

Nishy and Saroja[6] in their scientometric study analysed 1,09,766 publications covered in WoS during 1986–2015 depicts the developments and identified research outputs in the area of water quality research in India. Dhoble and Kumar[7] examined the publication activity in groundnut and mustard research in the world. This paper analysed 7463 papers published during 2000 -2013 and reports that journals have been used to publish 97.92 per cent of research publications. Gupta and Gupta[8] examined 432 Indian publications in the scopus database on knee osteoarthritis research (2007-16) and found 6.86 per cent annual average growth rate. It was found that global publication share of 24.05 per cent and qualitative citation impact averaged to 6.89 citations per paper and international collaborative publication share of 24.07 per cent. Sudhier and Dileepkumar[9] presents a study on the trends in authorship and collaborative research in the Indian biochemistry research covered in the Web of Science for a period of 10 years. Examined 25,132 research contributions and found that collaborative research is more in the field of biochemistry and 97.46 per cent publications are contributed by multi- authors. Other similar studies include: Ali *et al.*[10] analysed globally published research papers on Knowledge Sharing (KS); Sab, Kumar and Biradar[11] studied Indian chemical science research; Wani, Kharadi and Ganaie[12] studied the hepatitis research output indexed in the Web of Knowledge; Dhawan, Gupta and Gupta[13] examined global publications output on mobile computing research.

There are several bibliometric and scientometric studies that assess the Indian scientific research output in different subjects and disciplines. Vishnumaya, Nishy and Mini[14] studied Indian rare earths research; Hosamani and Bagalkoti [15] studied the Indian contributions in chemistry; Yeshawant and Ravi[16] on blood cancer research; Gupta et al.[17] analysed lung cancer; Dwivedi, Kumar and Garg[18] on organic chemistry; Sachithanantham and Raja[19] on rabies research; Sagar et al.[20] on electron probe microanalysis; biochemistry, genetics and molecular biology was studied by Nazir[21] ; Garg and Kumar[22] on life sciences; Aswathy and Gopikuttan[23] on spacecraft propulsion; Dutta and Rath[24] on carbon nanotube research; Thirumagal and Sethukumari[25] on cloud computing; Kanakaraj and Mohamed[26] on aquaculture research; Sudhier and Ravi[27] on marine fisheries research; Bagalkoti and Hosamani[28] on biochemistry and molecular biology.

Mishra and Balhara[29] on medical sciences in India; Gupta and Bala[30] on parkinson's disease; Gupta and Bala[31] on epilepsy research; Mohammed[32] on neuroscience research; Dutta and Rath[33] on cosmology research; Suresh Kumar[34] on human computer interaction; Gupta and Bala[35] on alzheimer's disease; Baskaran and Batcha[36] on cardiology literature; Gunasekaran and Balasubramani[37] on the artificial intelligence; Soumya Rani and Sudhier[38] on mathematics and Gupta and Bala[39] on asthma research. Review of previous studies portrays the absence of scientometric analysis on Indian biochemistry research and hence planned to undertake the present study.

2. OBJECTIVES

The major objectives are:

- To study the growth of biochemistry research
- To identify the major subject areas of research
- To study the bibliographic forms of publications
- To identify the top ranked authors and highly cited articles
- To study collaborative and co-authorship index
- To study the international collaboration
- To prepare the rank list of journals in biochemistry
- To study the geographical scattering of research
- To identify the various types of research institutions
- To examine the validity of Lotka's law of author productivity.

3. METHODOLOGY

The data for the study is accessed from Web of Science published by the Clarivate Analytics. The basic data relating to biochemistry publications from India for a period of 10 years (2004−13) are collected from web of science using general search options. The total population of present study consists of 25,132 research contributions covered in the database. In the address field of the general search option the word India was used. In the key word area, following key words were given- biochemistry in India, metabolism in India, proteins biochemistry in India, enzymes in India, and genetics in India. The retrieved data saved in text files were imported to Microsoft Excel for analysis. Finally the data was scientometrically analysed using SPSS software.

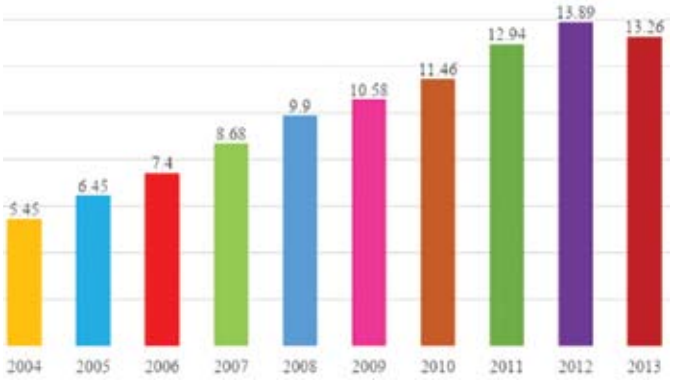

Figure 1. Year-wise distribution of biochemistry research output.

4. ANALYSIS AND DISCUSSIONS

4.1 Growth of Biochemistry Research Output

During the period of study, 25,132 articles on biochemistry and its sub-disciplines are published by Indian biochemists. Figure 1 depicts the year wise distribution of biochemistry

papers.

Analysis of the data indicates that the annual research output in Indian biochemistry increased throughout the period of study, with highest number of 3491 publications (13.89 %) in the year 2012 and average annual growth rate for the period is 36.84 per cent. A steady growth in number of publications has been observed from 2004 to 2012. In 2004, 1369 papers are published and this number rose to 3491 in the year 2012.

Here it can bee see that the highest number of contributions are in the year 2012. It is evident that biochemistry research in the country is growing steadily except in the year 2013.

4.2 Medium of Research Communication

Table 1. Bibliographic forms

Document type	Count	Percentage
Journal Articles	22478	89.43
Reviews	1796	7.14
Seminar Proceedings	486	1.93
Abstracts	165	0.65
Editorials	84	0.33
Letters	63	0.25
Book Chapters	38	0.15
Others	22	0.08
Total	25,132	99.96

Table 2. Subject-wise distribution of research output

Subject	Count	Percentage
Biochemistry & Molecular Biology	4915	19.56
Pharmacology & Pharmacy	2213	8.81
Biotechnology & Applied Microbiology	2209	8.79
Chemistry	1661	6.61
Plant Sciences	1457	5.80
Agriculture	963	3.83
Environmental Sciences & Ecology	904	3.60
Science & Technology	705	2.81
Food Science & Technology	641	2.55
Microbiology	623	2.48
Life Sciences & Biomedicine	600	2.39
Immunology	453	1.80
Cell Biology	449	1.79
Engineering	448	1.78
Neurosciences & Neurology	412	1.64
Oncology	395	1.57
Toxicology	358	1.42
Endocrinology & Metabolism	344	1.37
Genomics	343	1.36
Genetics & Heredity	330	1.31
Others	4709	18.73
Total	25,132	100.00

The Indian biochemists communicated their research results in variety of communication formats. The entire 25,132 papers are classified in to eight broad bibliographical forms and placed in their order of ranking in Table 1.

Table 1 shows that the medium of communication of research output are journal articles, which contribute 22478 (89.43 %) and are considered as an important primary source of information. It is followed by reviews (7.14 %) and seminar papers (1.93 %). These three bibliographic forms of documents together contribute 98.50 per cent of the total research output. Remaining 1.50 per cent records are scattered as abstracts, editorials, letters, book chapters etc.

4.3 Subject Profile of Biochemistry Research

The entire output in biochemistry is classified in to 20 disciplines. On classifying the total Indian biochemistry output under broad subjects, it is observed that majority of the publications is in the topic of biochemistry and molecular biology as shown in Table 2.

The research contributions in these sub-fields varied from 330 to 4915 papers. Analysis of biochemistry research output shows that 19.56 per cent (4915) of the total papers are in biochemistry and molecular biology, followed by pharmacology and pharmacy, toxicology and pharmaceutics (08.81 per cent share and 2213 papers) and biotechnology and applied microbiology (8.79 % share and 2209 papers).

4.4 International Collaboration

The scientific world is becoming increasingly interconnected with international collaboration. The study reveals that Indian biochemists have collaborated with thirty countries in their research. Figure 2 represent the collaborative nature of Indian biochemistry research. The international collaborative papers accounted for 17.59 per cent (4420) in the total research output of India in biochemistry research and the remaining 82.41 per cent papers are from India.

Table 3 describes the countries with which Indian authors collaborate in biochemistry research.

It is found that Indian scientists collaborated with 36

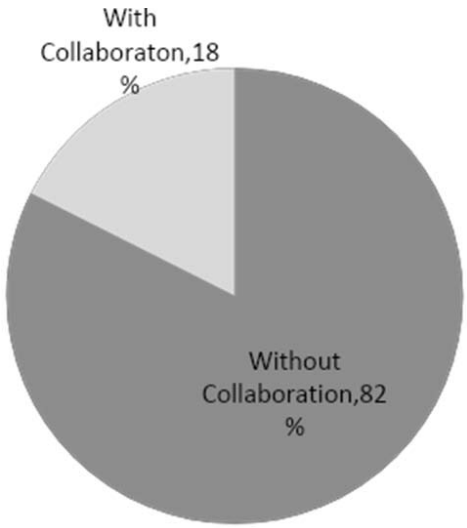

Figure 2. Distribution of nature of collaboration.

Table 3. International collaboration

Country	Year		Total
	2004-08	2009-13	
USA	521	1056	1377
Germany	162	190	326
UK	99	190	268
Japan	99	169	264
South Africa	66	177	243
France	72	121	193
Saudi Arabia	3	169	172
China	41	114	155
Canada	50	104	154
Australia	37	106	143

Table 4. Degree of Collaboration

Year	Single authors	Multi authors	Total	Degree of Collaboration
2004	44	1325	1369	0.97
2005	40	1581	1621	0.98
2006	50	1809	1859	0.97
2007	75	2106	2181	0.97
2008	80	2409	2489	0.97
2009	77	2581	2658	0.97
2010	80	2800	2880	0.97
2011	73	3179	3252	0.98
2012	58	3432	3490	0.98
2013	54	3279	3333	0.98

countries in biochemistry research. Among the countries, USA with top publications (1377), followed by Germany with 326 publications and UK with 268 publications. India's collaboration with Japan is the fourth highest followed by South Africa and France.

4.5 Authorship Pattern and Degree of Collaboration

The authorship pattern, one of the prime aspects of citation analysis mainly dealt with the kind of authors, degree of collaboration, collaborative trend etc. As biochemistry research is a laboratory-intensive activity, it is natural to find multi-authorship pattern. The analysis reveals that single author contribution is very less (2.51 %). Papers in biochemistry have been authored by 1 to 256 authors in the byline. Only 2.51 per cent of Indian research papers in biochemistry are single author papers and a majority of 97.48 per cent of papers are multi-authored. It is interesting to note that about 76.3 per cent papers have two to five authors. The highest number of publications i.e., 22.83 per cent was contributed by three authors, followed by 20.47 per cent two authors; and 19.50 per cent of papers contributed by four authors.

The formula given by Subramanyam[40] is used to determine the degree of collaboration of authors. The number of single and multi-authored contributions are calculated using the equation C=Nm/Nm+Ns

where C= Degree of collaboration in a discipline

Nm = Number of multi- authored papers

Ns= No. of single authored papers

In other words, it is the number of multi-authored papers divided by the total number of papers.

The degree of collaboration in different years is calculated and is tabulated in the Table 4 and are in the range of 0.97 to 0.98. This shows that most of the publications in biochemistry are collaborative work. However, the value of degree of collaboration is showing almost stable during the period of study.

Table 5. Co-authorship index

Year of publication	Single Authors	CAI	Two authors	CAI	More than two authors	CAI	Total
2004	44	128	340	121	985	93	1369
2005	40	98	358	108	1223	98	1621
2006	50	107	427	112	1382	97	1859
2007	75	137	501	112	1606	96	2182
2008	80	128	539	106	1870	98	2489
2009	77	115	540	99	2041	100	2658
2010	80	111	596	101	2204	99	2880
2011	73	89	614	92	2565	102	3252
2012	58	66	641	90	2791	104	3490
2013	54	65	589	86	2689	105	3332
Total	631		5145		19355		25132

4.6 Co-Authorship Index

It was observed that the co-authored papers are cited more frequently and the biochemistry research is no exception to this. Papers where Indian authors have foreign co- authors draw more citations than those having no international collaborations. The analysis shows that the value of CAI is increasing during the period of study. This implies that the collaboration in biochemistry is characterised by multi-authored contributions but not by single authored.

For calculating Co-Authorship Index (CAI), Garg and Padhi[41] proposed a formula-

CAI= ((Nij /Noj)/(Noj/ Noo))100

where Nij = number of papers having *j* authors in block *i*

Nio = total output of block *i*

Noj = No. of papers having *j* authors for all blocks.

Noo = total number of papers for all

Table 6. Top ranked authors

Author	Count	Percentage	Rank
Jaleel, C. Abdul	58	0.23	1
Pari, L	37	0.15	2
Kumar, S	26	0.10	3
Tripathi, G	24	0.10	4
Kumar, Manoj	23	0.09	5
Kumar, Puneet	22	0.09	6
Sharma, S	21	0.08	7
Kumar, Anil	20	0.08	8
Gupta, S	18	0.07	9
Kamal, A	18	0.07	9
Kumar, R	18	0.07	9

authors in all blocks

J = 1, 2, 3…N

The results of the analysis is shown in Table 5 and it indicate that three and more author papers are higher than that of single and two authored papers. Hence it can be inferred that collaborative research is prevalent in biochemistry research.

It is clear from the analysis that CAI is increasing and decreasing trend during the period of study. This implies that the collaboration in biochemistry research is mainly because of multi-authored papers and not by solo contributions.

4.7 Prolific Authors

Table 6 depicts the top contributions in biochemistry research during the period of study.

Total number of publications are contributed by authors ranging from single authors to 263 authors in a single paper. It shows that C. Abdul Jaleel is the most productive author contributing 58 papers (0.23 %) followed by L. Pari with 37 (0.15 %) papers and S. Kumar with 26 (0.10 %) papers.

4.8 Top Ranked Journals

The rank list of journals which together contributed a share of 4640 papers on Indian biochemistry for a period of ten years is shown in Table 7.

Analysis of the data for the distribution of biochemistry output indicates that Indian biochemistry literature is scattered in 2698 journals published from India and abroad. Of the 10 journals, seven are of international origin and only three are of Indian origin. It is found that *PLOS One*, USA tops the list with the highest number of publications of 296 (1.31 %) followed by *Bioresource Technology* with 294 (4.494 %) papers and *Applied Biochemistry and Biotechnology* with 263 publications. Among the top ranked journals, three Indian journals published by ICAR and CSIR-NISCAIR are included

4.9 Highly Cited Papers

Based on publication output of Indian biochemists, the highly cited 10 papers are identified with more than 300 citations and are shown in the Table 8. These 10 papers together received 4,486 citations.

Table 8 depicts that all the highly cited papers are covered in the international journals. The paper published in the journal *Science* by American Association for the Advancement Science (AAAS), USA has received highest citation (682) followed by the journal *Nature* (553) and *Ecotoxicology and Environmental Safety* (471).

4.10 Types of Institutional Contributions

It is found that there are many Indian institutions that have

Table 7. Top ranked journals

Name of journal	Country	Publisher	Rank	Count	IF	h-index
PLOS One	USA	Public Library of Science	1	296	3.234	127
Bioresource Technology	UK	Elsevier Academic Press	2	294	4.494	152
Applied Biochemistry and Biotechnology	USA	Humana Press	3	263	1.735	65
Indian Journal of Animal Sciences	India	ICAR	4	240	0.16	14
Molecular and Cellular Biochemistry	Netherlands	Springer	5	229	2.393	92
Indian Journal of Experimental Biology	India	NISCAIR - CSIR	6	222	0.835	49
Indian Journal of Biochemistry & Biophysics	India	NISCAIR - CSIR	7	201	0.871	25
Food and Chemical Toxicology	UK	Elsevier Academic Press	8	196	2.895	100
Process Bbiochemistry	UK	Elsevier Academic Press	9	192	2.516	95
World Journal of Microbiology & Biotechnology	USA	Springer	10	192	1.779	49

Table 8. Highly cited papers

Authors	Name of journal	Country	Year	Citation	IF	h-index
Schnable, Patrick	Science	USA	2009	682	31.03	851
Bateson, P	Nature	UK	2004	553	38.60	890
Parida, AK	Ecotoxicology and environmental safety	USA	2005	471	2.20	80
Parida, AK	Ecotoxicology and environmental safety	USA	2005	454	2.20	80
Loftus, B	Nature	UK	2005	447	38.60	890
Croft, SL	Clinical microbiology reviews	USA	2006	428	17.31	191
Brudey, Karine	Bmc microbiology	UK	2006	417	3.10	65
Sinha, VR	International journal of pharmaceutics	Netherlands	2004	352	3.46	139
Shanker, AK	Environment international	UK	2005	347	6.25	108
Rahman, Irfan	Biochemical pharmacology	UK	2006	335	5.01	152

Table 9. Types of institutional contributions

Institutions	2004-08		2009-13		Total	
	Count	%	Count	%	Count	%
Central Government	1149	4.57	1607	6.39	2756	10.96
State Government	110	0.43	226	0.89	336	1.34
Universities & Colleges	4527	18.01	8105	32.24	12632	50.26
Medical Colleges	829	3.29	1435	5.70	2264	9.008
Research Centers	2887	11.48	4257	16.93	7144	28.42
Total	9502	37.81	15630	62.15	25132	100.00

Table 10. State-wise distribution of publications

State	Count	Percentage	Rank
Tamil Nadu	3352	13.34	1
Uttar Pradesh	3214	12.79	2
Delhi	2853	11.35	3
Karnataka	2165	8.61	4
Union territories	2110	8.40	5
Maharashtra	2052	8.16	6
West Bengal	1821	7.25	7
Andhra Pradesh	1601	6.37	8
Haryana	1514	6.02	9
Punjab	754	3.00	10

contributed immensely to biochemistry research. Some of these institutions are owned by central and state government. Table 9 presents the type of various institutions of Indian biochemistry research.

The analysis shows that the universities and colleges together contribute 50.26 per cent papers, followed by research institutes with 28.42 per cent and central government institutions with 10.9 per cent of the total output. These three performing sectors together publish 89.64 per cent of the total output.

4.11 Geographical Distribution

Geographical distribution of publication share is presented in Table 10.

Analysis indicates that authors from almost all the states, except Bihar have contributed in biochemistry research. Seven states have contributed more than 1000 papers, Tamil Nadu and UP lead the list with 3352 and 3214 papers respectively. Other productive one's are Delhi (2853), Karnataka (2165) and Maharashtra (2052). The study revealed that, among the 29 states in India there is only one state which has no contribution in the subject for the period of study.

4.12 Appropriateness of Lotka's Law

Here the productivity of the Indian researchers in biochemistry is tested to find whether it will follow the Lotka's inverse square law[42] using the method proposed by Pao[43]. To verify whether the author's productivity frequency affirms the Lotka's law of author productivity or not, the Chi-square-goodness-of-fit test is applied to the data set. The Chi square test for observed and theoretical of authors are calculated and shown in Table 11.

$$C = 9692$$

$$n = 1.87571$$

By calculating the sum of all the difference between the square of observed and expected frequency $(fo\text{-}fe)^2$ and dividing it by the expected frequency i.e. $(fo\text{-}fe)^2/fe$, we get the Chi Square value. The Chi Square value obtained is 1284. Which are highly significant and greater than the expected value 3.94 at 5 per cent level of significance. Hence the law is

Table 11. Chi-square test

No. of papers (x)	No. of Observed authors(fo)	No. of expected authors (fe)	fo-fe	$(fo-fe)^2$	$(fo-fe)^2$
1	9692	9692	0	0	0
2	2641	2641	0	0	0
3	1017	1234	-217	47089	38
4	506	720	-214	45796	64
5	265	474	-209	43681	92
6	169	336	-167	27889	83
7	98	252	-154	23716	94
8	55	196	-141	19881	101
9	33	157	-124	15376	98
10	21	129	-108	11664	90
11	17	108	-91	8281	77
12	13	92	-79	6241	68
13	8	79	-71	5041	64
14	4	69	-65	4225	61
15	3	60	-57	3249	54
16	2	53	-51	2601	49
17	2	48	-46	2116	44
18	3	43	-40	1600	37
20	1	35	-34	1156	33
21	1	32	-31	961	30
22	1	29	-28	784	27
23	1	27	-26	676	25
24	1	25	-24	576	23
26	1	21	-20	400	19
37	1	11	-10	100	9
58	1	5	-4	16	3
		Chi square			1284

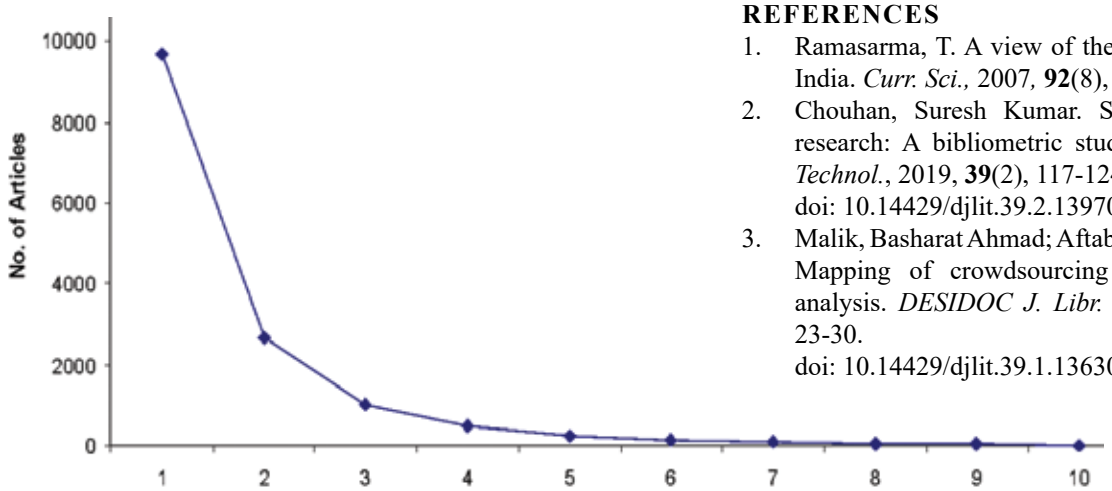

Figure 3. Number of authors vs number of articles.

find not in conformity with the present data set.

The fitness of Lotka's law is tested using Chi – Square statistical test. It is found that the obtained Chi – Square value is highly significant and greater than the expected value. Hence the Lotka's law does not follow the present author productivity distribution of biochemistry research. Hence the Lotka's law in its generalised form does not fit the contribution frequency of authors' productivity.

The graphical illustration of the author productivity data is shown in Fig. 3. The graph is plotted as the number of authors in X-axis and the number of articles in Y axis. Here the Lotka's law of scientific productivity is not in conformity with the present author productivity distribution.

5. CONCLUSIONS

Purpose of this study is to examine the trend of biochemistry research in India, using the number of papers covered by web of science. India had contributed 25,132 biochemistry publications in the Web of Science during the period of study. The cumulative Indian research output in biochemistry increased from 1369 papers in 2004 to 25,132 in 2013.It is a good indicator that publication output of India is increasing continuously in the last ten years. The study has identified the areas of research in biochemistry, journals used for communication, highly cited papers etc. India's publication output is 25,132 and it is the global publication share of 3.64 per cent. The world biochemistry contribution during the period is 6,91203 and India's average annual growth rate is 36.84 per cent. In terms of subject-wise contribution, the largest publication share comes from biochemistry and molecular biology (19.56 %). Tamil Nadu contributed the largest number of publications (14.5 %), followed by Uttar Pradesh (13.9 %). The most productive research institution contributing to biochemistry research is Council of Scientific and Industrial Research (CSIR). USA is India's largest collaborator producing 1577 co-authored papers during the period of study. The outcome of the study will be useful for the faculty members and biochemists who are active in the biochemistry research, and the policy makers and stakeholders in the country.

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