SCIENTOMETRIC ANALYSIS OF INDIAN BIOCHEMISTRY RESEARCH DURING 2010 – 2020

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This study examines the Biochemistry Researchin India applying scientometric parameters from 2010 to 2020 as per Scopus database. The paper uses year-wise distribution of publication, annual growth rate of publication, relative growth rate, doubling time of publication, annual growth rate, annual ratio of growth, authorship pattern, Co-Authorship Index (CAI), Degree of Collaboration (DC), Rate of Single Authorship, prolific author and affiliation, document-wise distribution of publications and most cited source and countries of collaboration with India. The study reveals that the Annual Growth Rate is maximum in the year 2011 which is 23.353 and number of publications are maximum in the year 2020 which is 2018 during the period of study 2010 to 2020. As per affiliations is considered the Banaras Hindu University has 443 number of publications, Kumar A is the most prolific author with 56 number of articles, most cited journal is *Journal of Biochemistry* with 1089 number of articles being cited, India has the highest number of collaborations with Korea (1117 publications) in the study period.

Keywords: Scientometrics, Biochemistry, Bibliometrics, Indian Publications, Lotka's Law, Scientometric indicators.

INTRODUCTION

Biochemistry is a prominent branch of both biological and chemical research also placed as a discipline in medicine. Basically, as the name suggests biochemistry is a branch of Science that deals with chemical processes that takes place within a living organism. Every living organism function only if they are provided with energy and generation of energy is from food materials consumed. Starting from digestion to conversion to energy is a complex process that involves lot of chemical process. Living organisms suffer from various diseases if the chemical processes do not occur properlywithin one's body. By using chemical knowledge and techniques in molecular and cellular levels Biochemists try to solve the

biological problems in living organisms. 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.

Indian Biochemistry literature is studied here on the basis of number of articles, citations, growth rate, doubling time, mean value, institutional collaboration, sources of collaboration, subject wise contribution of Indian researchers and international collaborations are studied with the data extracted from 2010 to 2020 from the Scopus database. The present study aims at analysing the research output of Indian Biochemistry researchers. The area wise research performance is analysed to identify the most popular area of research in Biochemistry. Moreover, an attempt has also been made to measure the performance of researchers and also analytical assessment of the articles published. Plenty of studies have been observed on Indian contribution to different subject areas. Some studies are observed on Chemistry literature based on Web of Science, Science Citation Index but that too in global aspects. A few studies have been also reviewed on Biochemistry literature analysis based on Web of Science database. But not a single recent study has been found on Indian Biochemistry research based on Scopus database.

The focus of scientometrics is the measurement of science and is therefore concerned with the growth, structure, inter-relationship, and productivity of scientific disciplines (Jeyasekar& Saravanan, 2015). There has been growing interest in mapping and visualization. In 1969, two Russian scientists Vassily V. Nalimov and Z. M. Mulchenko coined the Russian term “Naukometriya” equivalent to ‘scientometrics’. Tague-Sutcliffe (1992) defined “Scientometrics is the study of the quantitative aspects of science as a discipline or economic activity. It is a part of the sociology of science and has application to science policy-making. It involves quantitative studies of scientific activities including, among others, publication, and so overlaps bibliometrics to some extent”. Some studies on Scientometric assessment of Chemistry and Biochemistry research in global and Indian perspective are reviewed as per need.

LITERATURE REVIEW

Sudhier and Dileepkumar (2020) examined 25,132 biochemistry research contributions of Indian Scientists covered in Web of Science during 2004 - 2013. The study reveals that Biochemistry research is gradually growing with a growth rate of 36.84%. Collaborative research work is more common that single-authored papers as 97.46% papers are multi-authored. 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 a greater number of papers (50.26 %) followed by research institutions (28.24 %).

Ho and Hartley (2020)analysed the highly cited Phosphoinositide 3-Kinase research papers with data from Science Citation Index Expanded from 1900 to 2016. A total of 1922 highly cited papers in seven document types with at least 100 citations were encountered and a total of 1556 highly cited articles were published from 1900 to 2014. The Journal of Biological Chemistry led 211 journals. The U.S.A took the lead position among the 43 nations with 67% of the highly cited articles, the Harvard University, USA has 14% of the highly cited articles which is the most productive of all the institutions. The analysis of keywords revels that activation, pathway, Akt., Apoptosis is most recent in the field.Hosamani and Bagalkoti (2019) analysed the contribution of Indian chemistry literature as reflected in Web of Science database (Science Citation Index Expanded (SCIE) for the period from 1999 to 2013. The pioneers in chemical science literature have been conducted research works which has shown a steady growth of publications during the period producing 46,420 publications in total. Maximum publications are in the name of Council of Scientific Industrial Research, Delhi with the highest publication in the year 2013 and subject of maximum preference is Material Science. The most highly cited paper during the period is authored by Bharat Ratna Prof. C.N.R Rao, received with 1509 citations published in the year 2004. The study also reveals that collaborative research work is most common in the field of chemistry literature which is very usual in Science subjects.

The study by Amsaveni et al. (2013) shows that two authors collaboration contributed more than single authorship research articles.Saravanan and Dominic (2013) analysed international literature on Paleoecology as per the resources in Web of Science. The study reveals that sole authors are writing more papers than multi-authors. The h-index of the literature is 91. Kademani et al., (2006)attempted to highlight quantitatively the growth and development of world literature on Thorium in terms of publication output as per science citation index during 1982 - 2004. A total of 3987 papers were published in the period with an average of 173 publications published per year.

Though the previous studies focus on Bio-Chemistry and its allied subject research but the database considered is not Scopus. Moreover, a few studies have tested the fitness of Bibliometric Laws like Lotka's Law of Author productivity. The present study is based on data from Scopus and extensively applies Lotka's law is the dataset. Hence, the present study is conducte.

OBJECTIVES OF THE STUDY

The main objectives of the study are:

1. To analyse the growth of Bio-Chemistry research in India during 2010-2020.
2. To calculate Relative Growth Rate (RGR), Doubling Time (Dt), Annual Ratio of Growth

(ARoG), Annual Growth Rate (AGR) in biochemistry research in India

3. To find out the authorship pattern and the Degree of Collaboration (DC) in Indian Biochemistry research publications.
4. To identify the most prolific authors and their affiliation in Indian biochemistry research
5. To test the goodness-of-fit of Lotka's Law of author productivity to the collected data.
6. To find out the most cited source and countries of collaboration in biochemistry research in India.

METHODOLOGY

The study is based on the publication output based on Scopus database, the largest database with citation data of peer-reviewed literature from various disciplines, a product of Elsevier. The search string used to search for documents in Scopus database is ("Biochemistry") AND (LIMIT-TO (PUBYEAR, 2020) TO (PUBYEAR, 2010) AND (LIMIT-TO (AFFILCOUNTRY, "India"))). There are a total of 8526 records available in Scopus database as on 10th December 2020. The data is exported in CSV format and further scrutinized and MS-EXCEL was used for tabulation, statistical analysis and graph visualization. VoSViewerwas used for network visualization and mapping results.

DATA ANALYSIS

Document-wise distribution of Publications

The Table 1 depicts the document wise distribution of Publications on Biochemistry Research in India for the selected period of study. The observation of the analysed data reveals that the maximum of 6950 documents are articles, followed by 771 review type documents, book chapters, conference papers, Books, Letters, Erratum, Notes, Editorials, Short Survey, Retracted, data paper is 326,266,67,42,41, 24,23,8,6,1 respectively. 1 number of document has no source information.

Table 1: Form wise distribution of publications

Type of Document	Number of Documents (% of 8526)
Articles	6950 (81.52%)
Reviews	771 (9.04%)
Book Chapters	326 (3.82%)
Conference Papers	266 (3.12%)
Books	67 (0.79%)
Letter s	42 (0.49%)
Erratums	41 (0.48%)
Notes	24 (0.28%)
Editorials	23 (0.27%)
Short Surveys	8 (0.09%)
Retracts	6 (0.07%)
Data Papers	1 (0.01%)
No Source Information Available	1 (0.01%)
Total	**8526 (100%)**

Year-wise distribution of publications

The Table 2 and Figure 1show the year-wise distribution of publications in the discipline of Biochemistry Research from 2010 to 2020. The analysed data indicates that in 2010 the output was less low but started increasing after 2011 and it

touched highest at 2020. The highest, i.e. 1018 publications (11.94%) were published in the year 2020, followed by 876 in the year 2016 which is 10.27% of the total. The lowest publications are in the initial year of 2010 which is 501 in number and 5.88% of the total.

Table 2: Year-wise distribution of Publications

Year	Total No. of Publications	Percentage (%)	Cumulative Percentage (%)
2010	501	5.88	5.88
2011	618	7.25	13.13
2012	716	8.40	21.53
2013	709	8.32	29.85
2014	726	8.52	38.37
2015	795	9.32	47.69
2016	876	10.27	57.96
2017	847	9.93	67.89
2018	874	10.25	78.14
2019	846	9.92	88.06
2020	1018	11.94	100
Total	**8526**	**100**	

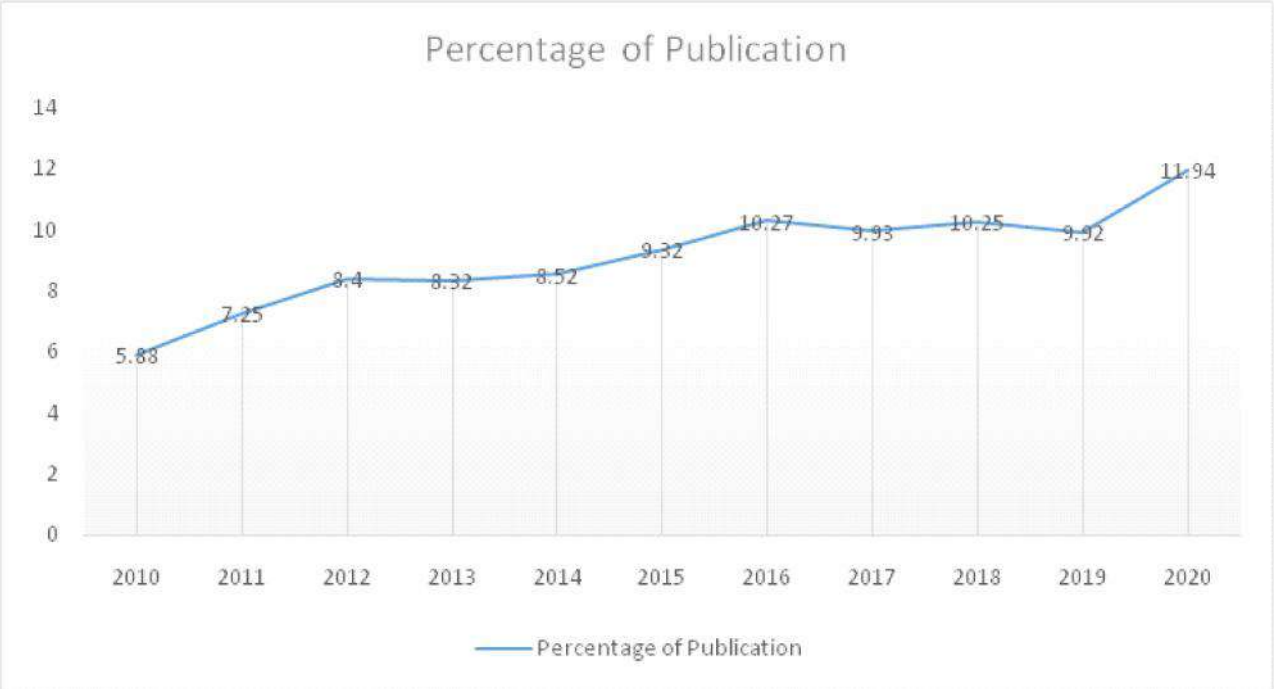

Figure 1: Distribution of Publications

Relative Growth Rate and Doubling Time of Publications

The Table 3 and Figure 2 shows the Relative Growth Rate and Doubling Time of the research publications in Biochemistry Research during the study period. The mathematical formula applied for calculation of RGR is,

RGR= $\frac{W2-W1}{T2-T1}$, **……** (1)

where,

RGR = Relative Growth Rate

W1 = Log_e(natural log of the initial number of contributions)

W2 = Log_e (natural log of the final number of contributions)

T1 = the unit of initial time

T2 = the unit of final time

This formula was developed by Mahapatra in 1985. RGR and Dt are the most common model for estimation of growth rate of publications. RGR is calculated to analyse the increase rate of publications with respect to time and Dt is related to RGR.

Doubling Time

The mathematical expression for calculation of Doubling Time (Dt) is,

Doubling Time (Dt) = $\frac{0.693}{R}$ **……** (2)

This was also formulated by Mahapatra. From the calculation it is clear that there is a direct equivalence existing between the RGR and Dt. If the number of publications of a subject double (2010-2020), then the difference between the logarithm of the numbers at the starting and at the last of the period must be the logarithms of the number 2. If one uses a natural logarithm then this difference has a value of 0.693 (Beaie and Acol, 2009).

The Table 3 shows that the maximum value of RGR is 0.804 was recorded in the year 2011, followed by 0.495 in the year 2012, the highest doubling time was recorded in the year 2019 which is 5.797, followed by 5.450 in 2020. The Figure 2 and analysed data in Table 3 implies that RGR is inversely proportional to Dt, as RGR increases the doubling time decreases and vice-versa.

Table 3: Relative Growth Rate and Doubling Time of Publications

Year	Number of Publications	Cumu-lative	W1	W2	RGR	Doubling Time	Mean RGR	Mean Dt
2010	501	501	0	6.217				
2011	618	1119	6.217	7.020	0.804	0.862		
2012	716	1835	7.020	7.515	0.495	1.401		
2013	709	2544	7.515	7.841	0.327	2.121		
2014	726	3270	7.841	8.093	0.251	2.760		
2015	795	4065	8.093	8.310	0.218	3.184		
2016	876	4941	8.310	8.505	0.195	3.551	**0.258**	**3.130**
2017	847	5788	8.505	8.663	0.158	4.380		
2018	874	6662	8.664	8.804	0.141	4.928		
2019	846	7508	8.804	8.924	0.120	5.797		
2020	1018	8526	8.924	9.050	0.127	5.450		

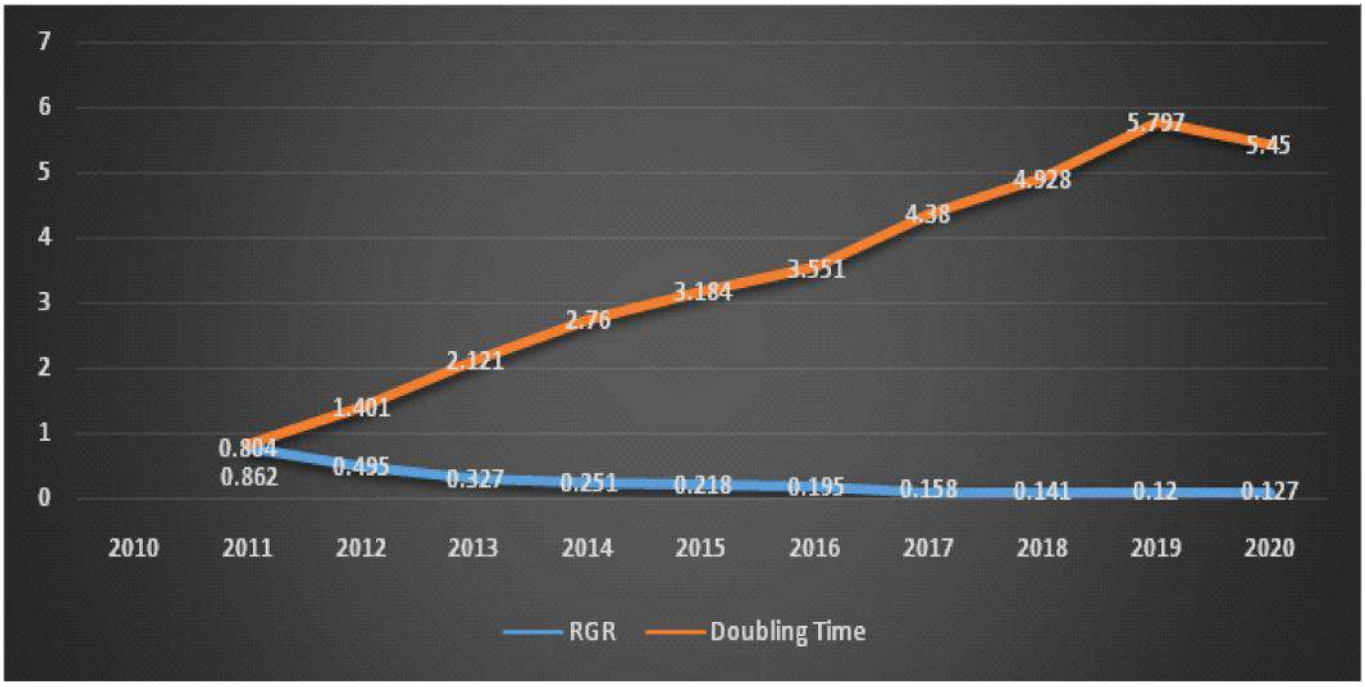

Figure 2: Relative Growth Rate and Doubling Time of Publications

Annual Ratio of Growth and Annual Growth Rate

The Table 4 and Figure 4 depicts Annual Ratio of Growth and Annual Growth Rate in Biochemistry Research in the period of study. The Annual Growth Rate (AGR) is calculated with the mathematical formula given by Kumar and Kaliyaperumal in 2015,

$$AGR = \frac{End\ Value - First\ Value}{First\ Value} X\ 100 \quad \ldots. (3)$$

The Annual Ratio of Growth is calculated with the formula,

$$ARoG = \frac{Last\ Year\ Output}{Current\ Year\ Output} \quad \ldots\ldots (4)$$

On observation of the Table 4 and Figure 4, it is clear that the maximum AGR 23.353 was recorded in the year 2011, followed by 20.331 was recorded in the year 2020 and 15.858 in the year 2012. The table also depicts the Annual Ratio of Growth and it is observed to be maximum in the year 2017 which is 1.034 and it is followed by 1.033 in the year 2019 and 1.009 in the year 2013.

Authorship Pattern and Degree of Collaboration

In order to measure the collaborative research pattern, an indicator, known as the Degree of Collaboration (DC), proposed by Subramanyam (1983), has been computed as under:

$$DC = \frac{N_m}{N_m + N_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where, N_m = Number of multi-authored or co-authored paper,

N_s = Number of single authored paper.

Table 4: Annual Growth Rate and Annual Growth Ratio

Year	Number of Publications	Annual Ratio of Growth	Annual Growth Rate
2010	501		0
2011	618	0.81068	23.35329
2012	716	0.863128	15.85761
2013	709	1.009873	-0.97765
2014	726	0.976584	2.397743
2015	795	0.913208	9.504132
2016	876	0.907534	10.18868
2017	847	1.034238	-3.3105
2018	874	0.969108	3.187721
2019	846	1.033097	-3.20366
2020	1018	0.831041	20.33097

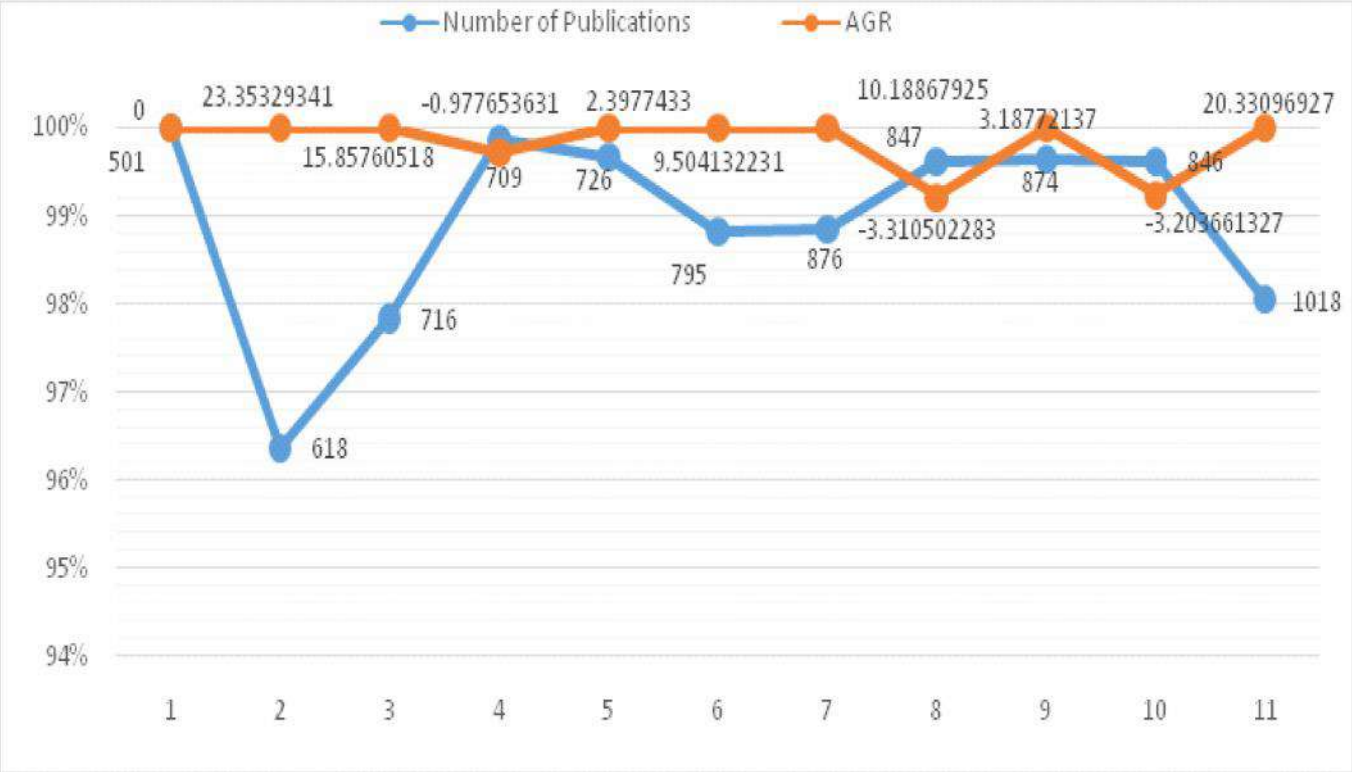

Figure 3: Annual Growth Rate and Number of Publications

The Table 5 depicts the authorship pattern and Degree of Collaboration in Bio-chemistry research during the period 2010 - 2020 in India. The Table indicates that the degree of collaboration i.e., DC= 7891 / (7891+635) = 7891/8526 = **0.93.** The authorship pattern of the publications in the period of study is presented.

Table 5: Authorship Pattern and Degree of Collaboration (DC)

Authorship Pattern in Indian Biochemistry Research		
Number of Single authored publications (N_s)	635	**Degree of Collaboration (DC) = 0.93**
Number of two authored publications (N1)	1567	
Number of three authored publications (N2)	1687	
Number of four authored publications (N3)	1566	
Number of five authored publications (N4)	1243	
Number of publications with more than five authors (N5)	1828	
Total number of publications (N)	8526	
Number of co-authored papers (N_m)	7891	

Analysis of Prolific Authors

The Figure 4depicts the most prominent authors in Biochemistry Research during the period of study. The Figure 4 visualizes the most prominent author in the field of Biochemistry Research. The highest 56 publications are contributed by Kumar, A., followed by Kumar S. with 33 publications, 31 publications by Sharma S. and the rest publications are in the name of the remaining authors.

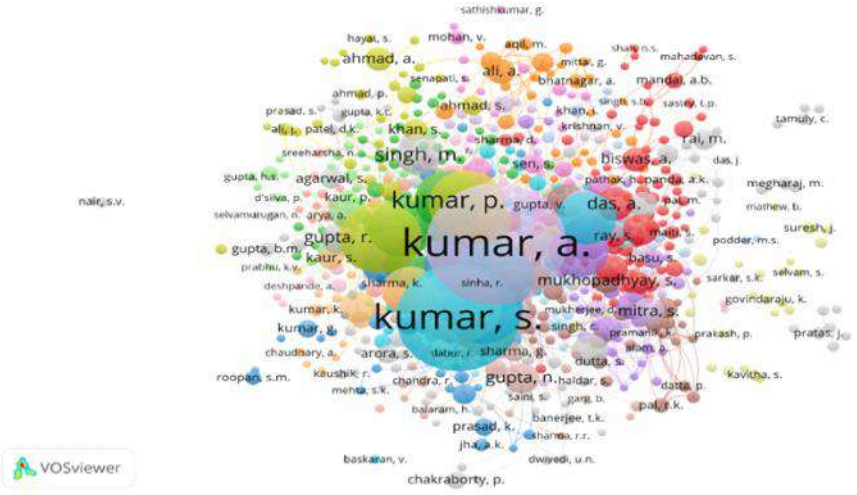

Figure 4: Visualization of prominent Authors in Biochemistry Research

Top 10 Prolific Institutions

The Table 6 illustrates the top 10 Indian Institutes/Affiliations on the basis of number of publications in Biochemistry Research. The top leading institute is prestigious the Banaras Hindu University with 443 publications, followed by Aligarh Muslim University with 401 contributions, followed by Indian Institute of Science, Bangalore with 381 contributions. The University of Calcutta being a state university has taken a position in top 10 with 356 publications in the sixth place. The Amity University being a private university with 313 publications is also in the top 8th position

Table 6 : Top 10 Prolific Institutions

Name of Institution	State/City	Number of Publications
Banaras Hindu University	Varanasi, U.P.	443
Aligarh Muslim University	Aligarh, U.P.	401
Indian Institute of Science	Bangalore, Karnataka	381
Jawaharlal Nehru University	New Delhi	377
Panjab University	Chandigarh, Punjab	367
University of Calcutta	Kolkata	356
Academy of Scientific and Innovative Research (ACSIR)	Chennai	335
Amity University	Noida, U.P.	313
Indian Institute of Technology, Delhi	Delhi	303
All India Institute of Medical Sciences	Delhi	298

Testing the goodness-of-fit of the Lotka's Law of author productivity by Kolmogorov-Smirnov (K-S) Statistical Test

Lotka was first to observe and analyse productivity patterns of Authors in a data sample from Chemistry and Physics. He came with a general formula known as Lotka's Law and can be written as:

$$x^n y = k \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Where, y is the frequency of authors making n contributions each and k is a constant.

The Lotka's Inverse square Law can be mathematically written as,

$$g(x) = \left(\frac{6}{p}\right)\left(\frac{1}{x^2}\right), \qquad x=1,2,3,4\ldots\ldots\ldots\ldots \quad (7)$$

where, g(x) is the proportion of authors making x contributions.

A generalised form of Lotka's Law was formulated by Bookstein (1979) as,

$g(x) = kx^{-n}$, where $x=1,2,3,4\ldots x_{max}$, $k>0$

$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$ (8)

where g (x) represents fraction of authors publishing x articles, k and n are the parameters to be estimated from the data, represents the maximum size or value of productivity variable x and n is usually greater than or equal to 1.

(a) Estimation of the parameter 'n'

The first step in application of the Lotka's law is to estimate the value of 'n', which is to be determined using the Least Linear Square (LLS) regression method or one of its equivalent form given by the formula:

$$n = \frac{[N \sum\{\ln(x).\ln g(x)\} - \sum \ln g(x) . \sum \ln x]}{[N \sum(\ln x)^2 - (\sum \ln x)^2]} \quad \ldots\ldots (9)$$

To compute the value of "n", x and g(x) is used, the Table 3 shows the calculations made:

Table 7: Calculation of 'n' with Straight count method

x	g (x)	ln (x)	ln g (x)	ln (x) * ln g (x)	ln x * ln x
1	6414	0.000	8.7662	0.0000	0.0000
2	742	0.6931	6.6093	4.8509	0.4805
3	222	1.0986	5.4027	5.9354	1.2069
4	95	1.3863	4.5539	6.3130	1.9218
5	38	1.6094	3.6375	5.8541	2.5903
6	17	1.7918	2.8332	5.0765	3.2104
7	19	1.9459	2.9444	5.7295	3.7866
8	8	2.0794	2.0794	4.3239	4.3241
9	10	2.1972	2.3025	6.7168	4.8277
10	8	2.3025	2.0794	4.7878	5.3015
11	5	2.3979	1.6094	3.8591	5.7499
12	2	2.4891	0.0693	0.1724	6.1956
Total	**7580**	**19.9912**	**42.8872**	**53.6194**	**39.5953**

Substitution of these values from the table in Equation 9, we calculate the value of 'n' as,

$$n = \frac{12 \times 53.6194 - 42.8872 \times 19.9912}{12 \times 39.5953 - 399.6481} = -2.8337$$

(a) Estimation of the parameter 'k'

The value of k, which is the theoretical number of authors with a single article is determined from the formula:

$$k = \frac{1}{\sum_{x=1}^{p-1} \frac{1}{x^n} + \frac{1}{(n-1)(p^{n-1})} + \frac{1}{2}p^n + \frac{n}{24\,x\,(p-1)^{n+1}}} \quad \ldots\ldots\ldots (10)$$

here, p is assumed to be 20 and n is the experimentally computed value of the exponent from the observed distribution.

If the value of n and k is determined, then using equation 8, the number of authors is determined writing 1,2,3……., x.

The value of k is determined by taking the corresponding value of n = -2.8337 from the table of exponents given by Rousseau (1993) as the value of k is 0.82.

(c) Fractional value of the expected number of authors is calculated by placing the value of n and k in equation 8 as,

$$g(1) = \frac{0.82}{1^{2.8337}} = 0.82,\ g(2) = \frac{0.82}{2^{2.8337}} = 0.1150 \ldots\ldots \text{up to } g(12)$$

These values are shown in column 6 of Table 8.

(d)Sustainability of Lotka's Law using Kolmogorov-Smirnov (K-S) Statistical Test

As recommended by Coile (1977) K-S Statistical test is applied to test the fitness of Lotka's Law for which the observed and expected number of

authors are converted into fractional values and the difference between cumulative fractional values of observed and expected number of authors is evaluated as shown in Table 8.

Table 8: K-S Test for observed and expected distribution of authors

x	g(x)	FOF	CFOF	FEF	CFEF	DOECF
1	6414	0.8441	0.8441	0.8200	0.8200	**0.0241**
2	742	0.0975	0.9416	0.1150	0.9350	0.0066
3	222	0.0292	0.9708	0.0365	0.9715	-0.0007
4	95	0.0116	0.9824	0.0161	0.9876	-0.0052
5	38	0.0053	0.9877	0.0086	0.9962	-0.0085
6	12	0.0024	0.9901	0.0051	1.0013	-0.0112
7	19	0.0018	0.9919	0.0033	1.0046	-0.0127
8	8	0.0014	0.9933	0.0023	1.0069	-0.0136
9	10	0.0011	0.9944	0.0016	1.0085	-0.0141
10	8	0.0009	0.9953	0.0012	1.0097	-0.0144
11	5	0.0007	0.9960	0.0009	1.0106	-0.0146
12	2	0.0004	0.9964	0.0007	1.0113	-0.0149

g (x): *Number of Authors contributing x number of papers*

FOF: *Fraction of Observed Frequency of Authors*

CFOF: *Cumulative fraction of observed frequency of authors*

FEF: Fraction of expected frequency of authors

CFEF: *Cumulative fraction of expected frequency of authors*

DOECF: *Absolute difference of the observed and expected cumulative frequency of authors*

The maximum difference of value, D_{max} in observed and expected frequency of authors is identified as 0.0241 as marked in Column 7 of Table 8.

The table value or critical value of D in K-S test at 5% level of significance is 0.5632. But comparing it with actual value of D which is 0.0241 with critical value 0.5632 it is evident that the actual value of D does not fall within the critical value of D. Therefore, Lotka's law does not fit the author productivity distribution for the first authors in Indian Biochemistry literature.

Countries of Collaboration with India

The Table 10 and Figure 5 depict the top 10 countries in collaboration with Indian Authors. Indian authors have highest number of contributions with authors of India only which numbers 1525. This is followed by collaboration

with Korean authors which counts 1117, followed by USA with 994 articles, China with 968, Saudi Arabia with 908 publications. The rest of the top 10 nations along with number of articles are tabulated below.

Table 10: Number of articles and top 10 most collaborating countries with India

Country	Articles	Number of Citations
India	1525	2420
Korea	1117	1974
USA	994	1756
China	968	1668
Saudi Arabia	908	1524
Australia	885	1316
Belgium	863	1298
Canada	803	1204
Germany	793	1188
Singapore	668	1080

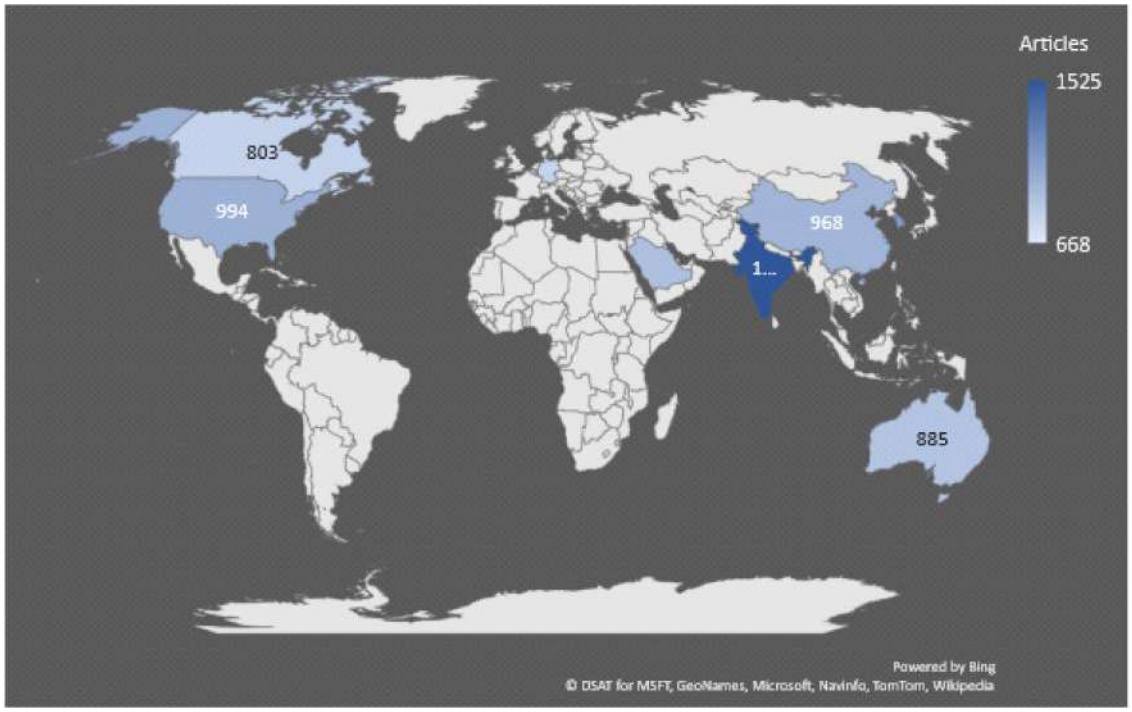

Figure 5: Top 10 Corresponding Author's with India and their Countries

CONCLUSION

Biochemistry is a branch of Science that explores chemical process in and related to any living body. A complete laboratory-based science that brings chemistry and biology together. Numerous molecular level research is going on in this discipline of biochemistry to explore chemical reactions in a living organism that are related to life processes. Enzyme related reactions are studied to understand and apply necessary in any reaction to take place in a living organism. Biochemistry covers range of scientific disciplines including genetics, microbiology, forensics, plant science, medicine. Biochemists have been incessantly working on to provide new ideas and experiments to understand the metabolism of life, understanding of health and disease, contributing innovative information to the technology revolution. In a nutshell, biochemists have lot to do in understanding the life processes of any living organism.

This paper highlights the scientometric parameters of Biochemistry Research reveals that India has the highest collaboration with Korea (1117 publications), most cited journal is *Journal of Biochemistry* with 1089 number of articles being cited, as per affiliations is considered the Banaras Hindu University has 443 number of publications, Kumar A is the most prolific author with 56 number of articles, as per document type is concerned Journal articles are maximum in number which is 6950, Annual Growth Rate is maximum in the year 2011 which is 23.353 and number of publications are maximum in the year 2020 which is 2018 during the period of study 2010 to 2020.

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