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Nanotechnology Research in SAARC Nations during 1996 to 2020: A Scientometric Assessment based on Scopus Database

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Abstract

The study investigates Nanotechnology Research during 1996 to 2020 using Scopus Database. It attempts to quantify the national contribution to Nanotechnology Research highlighting the growth of research in the SAARC nations using different scientometric indicators. The results of the study show the Growth Rate, Annual Growth percentage of the publications, most prolific author, application of Lotka's Law of Scientific Productivity, most prolific journal, institution, funding agency, geographical distribution and document forms of the publications in Nanotechnology during 1996 to 2020 downloaded in a suitable retrieval technique from the Scopus database. The results reveal that Indian Contribution in Nanotechnology Research is excellent among SAARC nations. Bhutan and Maldives have no record of Publication in Scopus database in the period taken for study.

Keywords: Nanotechnology, Scientometrics, Scopus, SAARC Nations, Research Collaboration, Lotka's Law

1. Introduction

Scientometric Analysis is involved in analysis of scientific productivity of measuring and analysing scientific fields. The quantitative assessment of publication productivity by scientometric parameters is a very reliable technique to understand the impact of any research in a community. This study explores the performance of SAARC nations in the field of Nanotechnology by using scientific research through quantitative metrics of Scientometrics and Bibliometrics.

The concept of Nanotechnology arises in 1959 when Richard Feynman described the possibility of synthesis thorough manipulation of matter at atomic level. The term Nanotechnology is having two terms interconnected Nano meaning 10^{-9}scale and Technology meaning technology application in 10^{-9}scale of any matter. This definitely concerned with atomic or molecular or cellular (in case of living being) levels. There is an interesting observation by some scientists working in the discipline of Nanotechnology that any matter that is taken into the nano scale shows difference in chemical and physical properties like melting point, boiling point, chemical reaction, hardness, colour changes to an unbelievable extent. This characteristic of matter in the raw state is utilised in industry and more efficient products are manufactured from the materials. So, Nanotechnology has widespread application in almost every industrial sector including medicine. Nano-medicine have proved to be more efficient than regular medicines. Medical Science is also extensively using the concept of Nanotechnology to cure deadly diseases like Cancer. Nanoelectronics, Biomaterial Energy Production are also evolving products of Nanotechnology.

2. Review of Literature:

Deka and Hazarika (2020) analysed Nanotechnology Research with special reference to India during the period 2008 to 2017. A total of 16935 articles were retrieved and this forms the basis of this study. The growth of the article over the study window is 123 articles per year. 2017 is the most productive year with 2220 (13%, approx.) articles. Journals and authors' productivity are analysed based on their h-index and z-index. Among the 30 top productive journals taken for the study, ACS Nano is occupying the top position in nanotechnology research with 400 articles. The paired t-test showed a strong and significant correlation of h-index and z-index of authors and journals. The top ten leading countries have also been identified in the study and the USA has topped the rank with 29.68% of world share publication while India is in third position with 7.29% of share next to China (i.e., 15.23%). The same rank is observed for India in the Relative Citation Impact, however, with below world average (i.e., 0.81). This study will be beneficial for the library staff as well as for the Nanotechnology researchers towards identifying the most productive works, the most prolific authors and organizations affiliated to those works.

Sudhier and Jahina (2020) analysed Indian Bioinformatics Research during 2011-2019 using Web of Science database. It attempts to quantify the national contribution to growth efforts and identify areas of citation, h-index and highly cited articles. The study also highlighted the growth of Indian bioinformatics output using different scientometrics indicators. The results

reveal that the most productive year is 2019 with 188 publications (18.13%), three authored papers are maximum 269 publications as per the forms of the document is considered articles are maximum in number 1108. The top ranked journal in bioinformatics on the basis of citation, h-index and articles are *PLOS One* and *Gene*. The most highly cited paper is for Kumar A with 26 total citations in the year 2013. The study also covers for funding agencies in bioinformatics research. UGC, CSIR, DST and DBT are the major funding agencies that are responsible for more contributions in bioinformatics research in India.

Chauhan (2019) 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. The 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 (2019) presented a bibliometric examination of the crowd sourcing publications by using web of science for a period between 2008 and 2017. In study 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. Pandey, Verma and Shukla (2019) used various scientometric indicators like year wise growth rate, more productive authors, source wise, subject wise and funding agencies. Council of scientific and industrial agencies (CSIR) has the most popular funding agency in bioinformatics research in India. Chakrabooty, C is the most prolific author in bioinformatics research and this research concluded that growth of bioinformatics is steadily increasing trend. Sab, Kumar and Biradar (2018) carried out the medical research in India and their study focused in growth and International collaboration. Gopal and Sudhier (2017) conducted the study about collaborative research in bioinformatics in India and results found that the degree of collaboration was 0.91 and highest publications covered from collaboration publications. Gopal and Sudhier (2015) studied qualitatively the growth of bioinformatics research in India. This study found that degree of collaboration was 0.93 and most publications for journal article compared to other documents. Bradford's law of scattering not fit for this study. Dutta and Rath (2013) studied on the cosmology research in India. Sudhier and Dileep Kumar (2010) in their study determined the bibliometric characteristics of the biochemistry research in the University of Kerala, India, including subject wise break-up, bibliographic forms of cited documents, most cited journals, collaboration in authorship, etc. Molatudi, Neo and Pouris (2009) contributed the Bibliometrics tools and techniques, the 808 records for South Africa research during the

period 16 years from 1990 to 2006 which was equivalent to world output 0.35%. Glanzel, Janssens and Thijs (2009) analysed the citation impact and publication activity in bioinformatics research, this analysis based on quantitative analysis. National publication activities and international collaboration analysed in this comparative study.Patra and Chand (2005) examined the Biotechnology research in India and found that maximum 89% research papers were formed of collaborative authorship and Ravishankar, GA was the most prolific author with 45 publications from Central food technology research institute Mysore.

3. Scope of the study

The scope of the study is limited to scientometrics analysis of nanotechnology research appeared in Scopus database and SAARC countries only except Bhutan and Maldives because the data of these two countries are not available in the SCOPUS database. Also, the study period is limited to 1996 to 2020 and literature published in English language only.

4. Objectives of the study

1. To find growth rate and annual growth percentage of the publications.
2. To find the top prolific authors in the field of nanotechnology research on the basis of number of publications.
3. To examine the validity of Lotka's Law using total count and straight count of authors.
4. To find out the most prolific Journal, prolific institution, funding agency and geographical distribution of documents in the field of nanotechnology.
5. To examine the document forms of publication.

5. Methodology

The study examines the scientific publications generated in the discipline of "Nanotechnology" by researchers of SAARC countries through a systematic search of Scopus database. The retrieval was restricted to publications produced in the time period 1996 to 2020. A total of 12,285 publications were found in the chosen time period. The data is downloaded in CSV format and the analysis of data is done using MS-EXCEL and Biblioshinysoftware through R-platform.

6. Analysis and Interpretation

6.1 Year-wise distribution of Publication Growth

Table 1 and figure 1 below depicts the year-wise growth of publications during the study period of 1996 to 2020 in Nanotechnology Research contributed by SAARC countries. From the table it is quite clear that there in growth in the number of publications from 1996 to 2020 onwards. The highest number of articles are published in 2019 (1585, 0.123% of the total) and least number of articles are published in the year 1998 and 1999 (1, 0.00081% of the total). There is reasonable growth of literature seen during the period of study.

Table 1: Year-wise distribution of Nanotechnology Research Publications

Year	Number of Publications	%	Cumulative Publications	Growth Rate	Annual Growth Percent (%)
1996	3	0.024	-	-	-
1997	3	0.024	6	0	0
1998	1	0.00081	7	-0.66	-66.66
1999	1	0.00081	8	0	0
2000	3	0.024	11	2	200
2001	13	0.001	24	3.33	333.33
2002	38	0.003	62	1.92	192.31
2003	64	0.0052	126	0.68	68.42
2004	104	0.0085	230	0.63	62.5
2005	119	0.0097	349	0.14	14.42
2006	179	0.015	528	0.50	50.42
2007	257	0.021	785	0.44	43.58
2008	291	0.024	1076	0.13	13.23

2009	351	0.029	1427	0.21	20.62
2010	481	0.039	1908	0.37	37.04
2011	567	0.046	2475	0.18	17.88
2012	653	0.053	3128	0.15	15.17
2013	913	0.074	4041	0.40	39.82
2014	812	0.066	4853	-0.11	-11.06
2015	933	0.076	5786	0.15	14.90
2016	1084	0.088	6870	0.16	16.18
2017	1158	0.094	8082	0.07	6.82
2018	1292	0.105	9320	0.12	11.57
2019	1585	0.123	10905	0.23	22.68
2020	1380	0.112	12285	-0.13	-12.93
Total	12285				43.61

6.2 Annual Growth of Publications

Annual Growth Rate of Publications is calculated with the formula 1below suggested by Santha and Kaliyaperumal (2015) as:

$$R = \frac{P_1}{P_0} \; x \; 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where,

R= Publication Growth in Percentage,

P_1 = Number of Publications in the present year,

P_O= Number of publications in the previous year

The figure 1 below depicts the annual growth of publications and the year-wise annual growth is shown in the table 1 above. There are a total of 12,285 publications in the period of study with an average annual growth rate of 43.61%. There is positive growth rate observed in the year 2000 to 2013 and from 2015 to 2019. Negative growth rate is observed in the year 1998, 2014 and 2020. Neutral growth rate is also observed in 1997 and 1999. The highest annual growth rate is observed for the year 2001 (333.33%) and lowest annual growth rate is observed in the year 1998 (-66.67%).

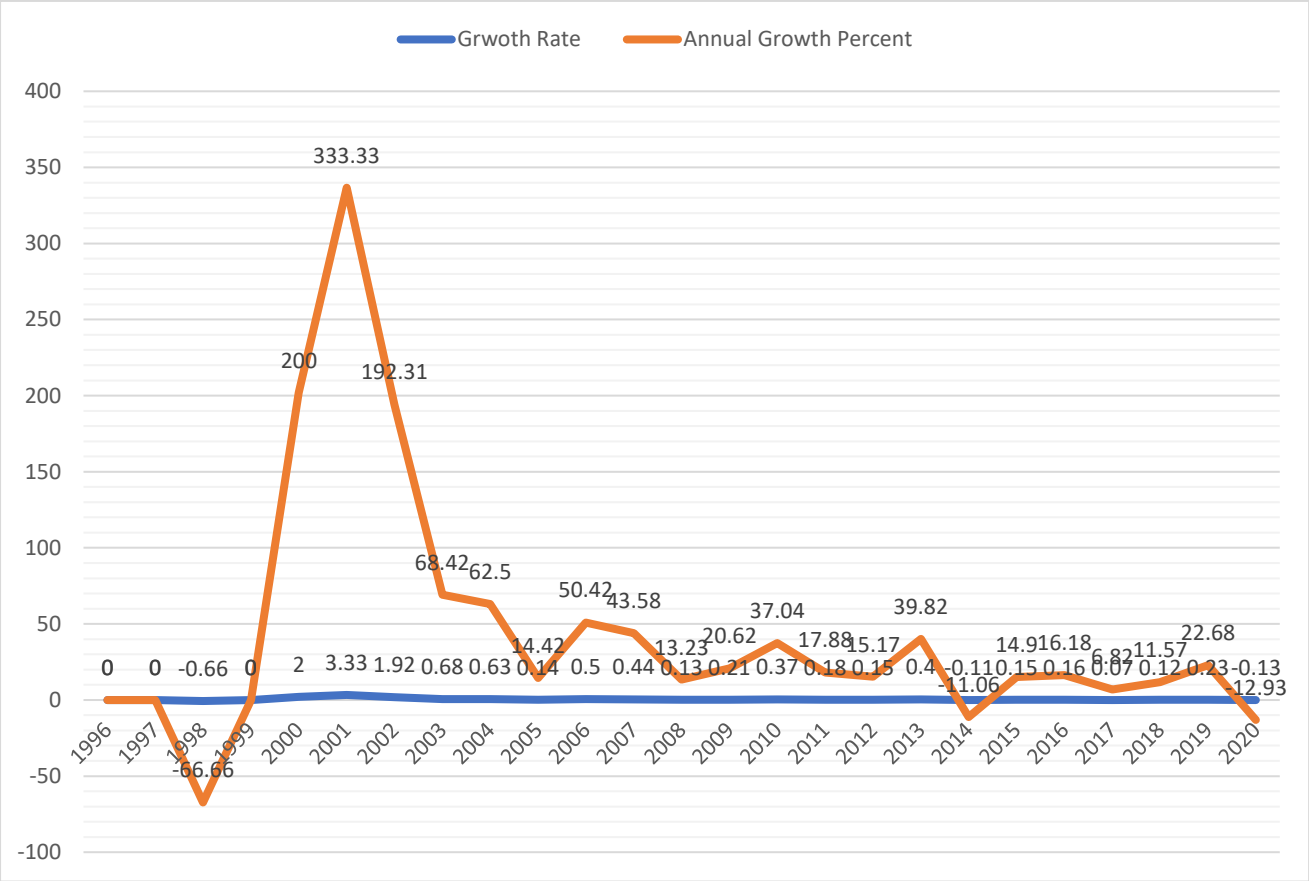

Figure 1: Annual Growth of Publications in Nanotechnology

6.3 Most Prolific Author

Figure 2 depicts the top 10 most prolific author in the time period taken for study in Nanotechnology research. The observation of the table 1 reveals that the most of the prolific authors in the field of Nanotechnology Research are Indian. The maximum number of publications are in the name of Rai, M with 85 publications this is followed by Rajeshkumar, S and Thomas, S. with 52 publications each. One of the renowned Indian scientist Bharat Ratna Prof. C.N.R. Rao has 48 publications, Ahmad, F.J. has 41 publications.

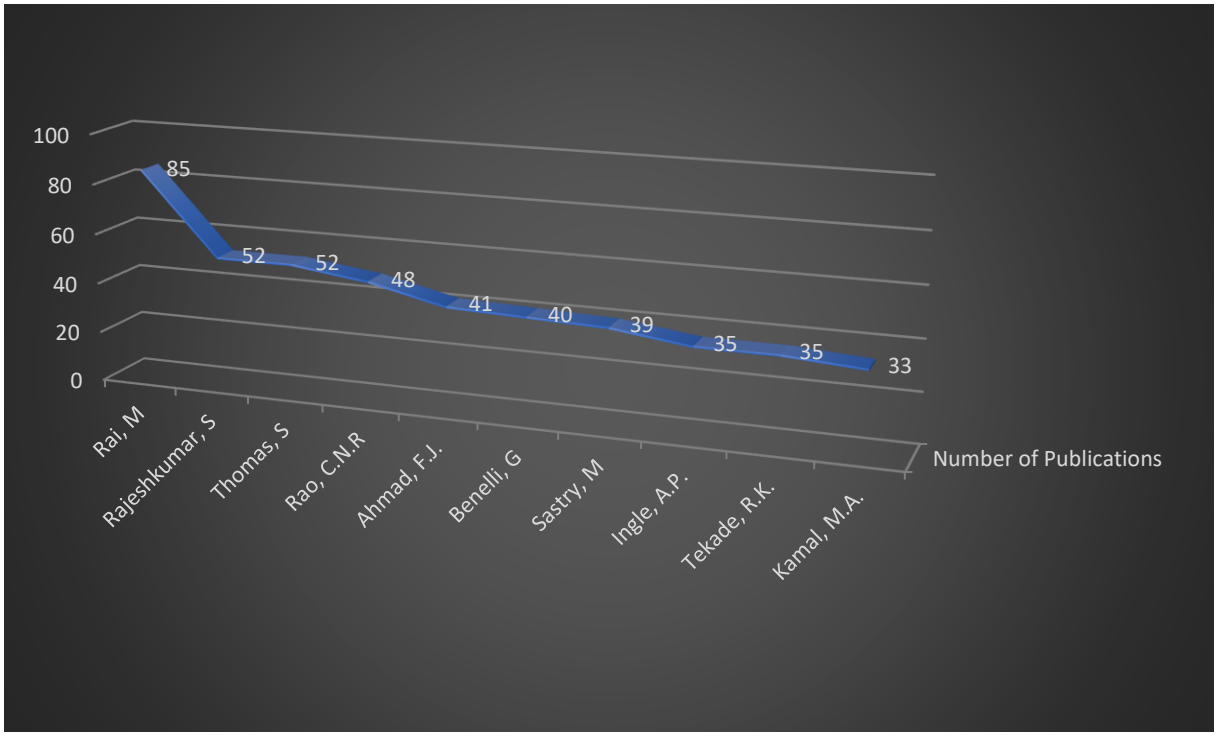

Figure 2: Top 10 Most prolific author in nanotechnology Research

6.4 Application of Lotka's Law of Scientific Productivity

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:

$x^n y = k$ …….. (2)

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,

$g(x) = (\frac{6}{p})(\frac{1}{x^2})$, x=1,2,3,4……. …… (3)

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

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

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

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

Data set for the straight count method

Calculation of Parameter "n"

The first step to test the validity of Lotka's law is to determine the value of "n", which is to be determined by Linear Least Square (LLS) method by using the formula (5).

$$n = \frac{[\,N\ \sum(\ln x - \ln g\ (x)\,) - \quad \sum \ln g\ (x) \sum \ln x]}{[\,N\ \sum(\ln x)^2 - (\sum \ln x)^2]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

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

Table 2: 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	4235	0.000	8.3511	0.0000	0.0000
2	565	0.6931	6.3368	4.3920	0.4805
3	160	1.0986	5.0751	5.5755	1.2069
4	90	1.3863	4.4998	6.2380	1.9218
5	56	1.6094	4.2054	6.4784	2.5903
6	26	1.7918	3.2580	5.8377	3.2104
7	11	1.9459	2.3978	4.6659	3.7866
8	9	2.0794	2.9172	6.0060	4.3241
9	8	2.1972	2.0794	6.0060	4.8277
10	1	2.3025	0	0.0000	5.3015
Total	**5161**	**15.1042**	**38.9406**	**45.1995**	**27.6408**

By substituting the values in the table above the value of "n" can be calculated using the formula (5),

$$n \;=\; \left[\frac{10\ x\ 45.1995 - 38.9406\ x\ 15.1042}{10\ x\ 27.6498 - 228.1369}\right] = 1.5616$$

The value of "n" is further used for testing the Lotka's Law of author productivity. The table 4 below depicts the number of authors observed and number of authors expected as their respective percentages.

Table 3: Number of Authors Observed and Expected

No. of Articles (x)	No. of Authors Observed {g (x)}	Percentage Observed	No. of Authors Expected ($\frac{g(x)}{x^n}$), where (n=1.5616)	Percentage of expected authors
1	4235	82.06	4235	82.06
2	565	10.95	191	3.70
3	160	3.10	29	0.562
4	90	1.74	10	0.19
5	56	1.085	5	0.09
6	26	0.50	2	0.039
7	11	0.00	1	0.019
8	9	0.00	0	0
9	8	0.00	0	0
10	1	0.00	0	0

The table 3 above and figure 3 below depicts the application of Lotka's Law of Scientific Productivity on the data set obtained from Scopus database on Nanotechnology Research by SAARC nations during 1996 to 2020. The results indicate that one number of articles was published by 4235 authors representing 82.06 %, which is both observed and anticipated. Two article contribution i.e., 565 constituting 10.95 %, while 191 authors for 2 articles constituting 3.70% were expected. Hence, it is observed that the number of authors observed are having much difference with number of authors expected, so it disobeys Lotka's Law of Productivity.

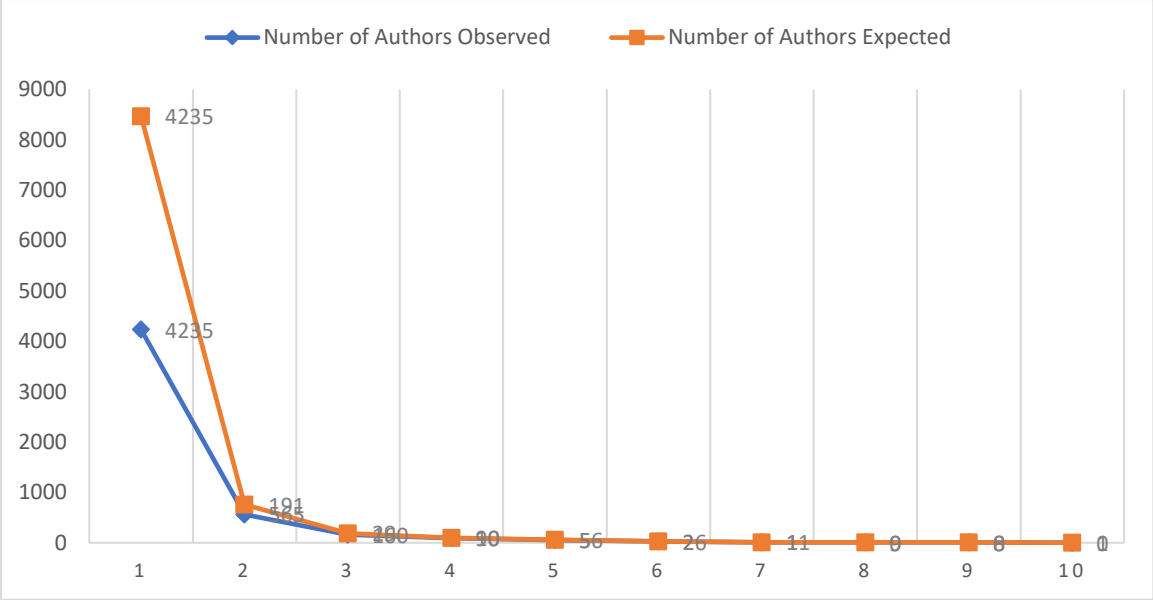

Figure 3: Application of Lotka's Law of Scientific Productivity

6.5 Most Prominent Journal

The table 4 depicts the most prominent source in the field of "Nanotechnology" during the study period. The observation of the table reveals that the maximum number of articles 329 in number are published in Journal of Nano-Science and Nanotechnology, published by American Scientific Publishers followed by Materials Today Proceedings with 163 articles which is an open access journal published by Elsevier. This is followed by Colloids and Surfaces B Bio interfaces with 106 articles.

Table 4: Top 10 most prominent Journals in Nanotechnology Research

Name of the Journal	Number of Documents
Journal of Nano-Science and Nanotechnology	329
Materials Today Proceedings	163
Colloids and Surfaces B Bio interfaces	106
Nanotechnology	89
International Journal of Biological Macromolecules	80

Journal of Nanoparticle Research	74
Current Pharmaceutical Design	70
Research Journal of Pharmacy and Technology	67
Journal of Physics Conference Series	67
Iet Nanobiotechnology	66

The figure 4 below depicts the Publications per Year and the name of the Journal. The observation of the figure below it reveals that maximum numbers of articles are published in the year 2019 in Materials Today Proceedings and this is followed by Journal of Nanoscience and Nanotechnology in the year 2007.

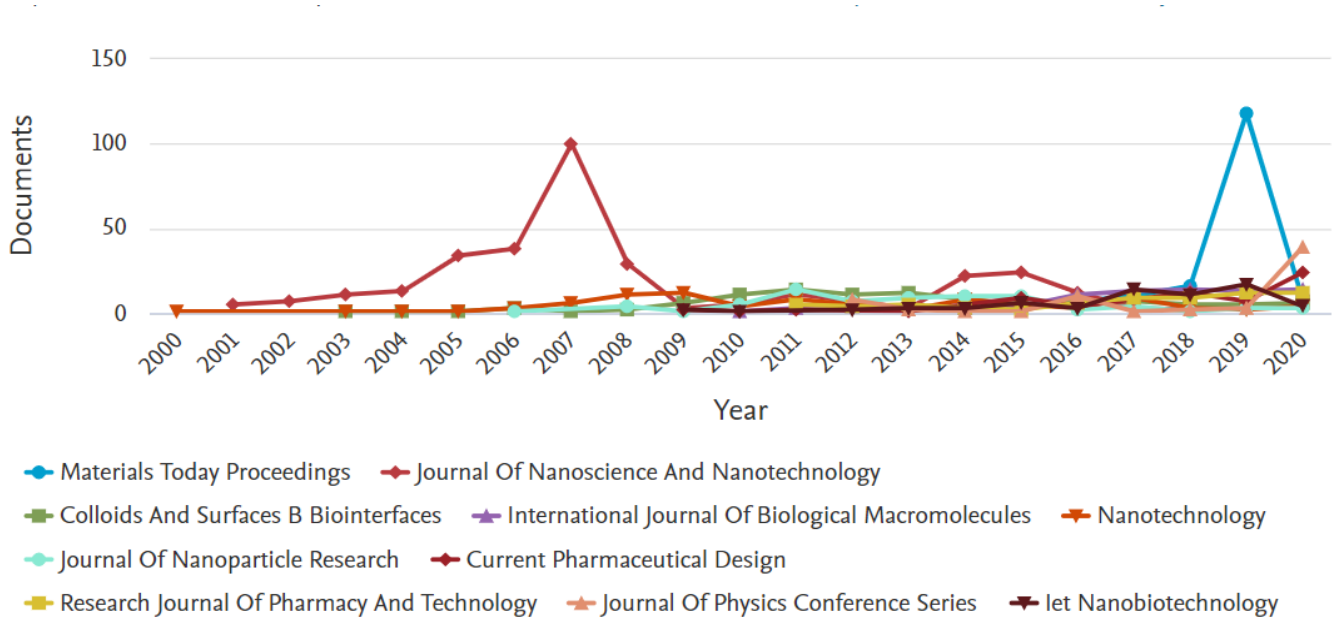

Figure 4: Number of Publications per year in the top 10 prolific journals

6.6 Most Prolific Institution

The figure 5 below indicates the most prominent institution in the field of Nanotechnology Research in the time period (1996 to 2020) taken under study. The figure gives a very delightful picture for India in Nanotechnology Research because almost all the top 10 most prolific institutions are Indian Institutions. Maximum numbers of articles are produced by Indian Institute of Science (IISc),

Bangalore (244) this is followed by 222 articles by Indian Institute of Technology (IIT), Bombay, after it there are 208 publications for IIT Delhi, 203 publications by IIT Kharagpur and in this category of National Institutes of Importance we have IIT, Madras 143 publications. Two premier private institutions Vellore Institute of Technology, Vellore and Amity University Noida have found their places in top 10 which is a matter of proud being an Indian which implies that research and development activities have been also extensively growing in the private sector of India. Research laboratories under Council of Scientific and Industrial Research (CSIR) are also performing well in Nanoscience with 188 publications it has also occupied a position in the top 10. Among the Central Universities of India University of Delhi has also found its position with 175 publications. Another matter of pride is for Jadavpur University, being a state university in India that it has got an international recognition in Nanotechnology Research with 133 publications in the tenth position in the list.

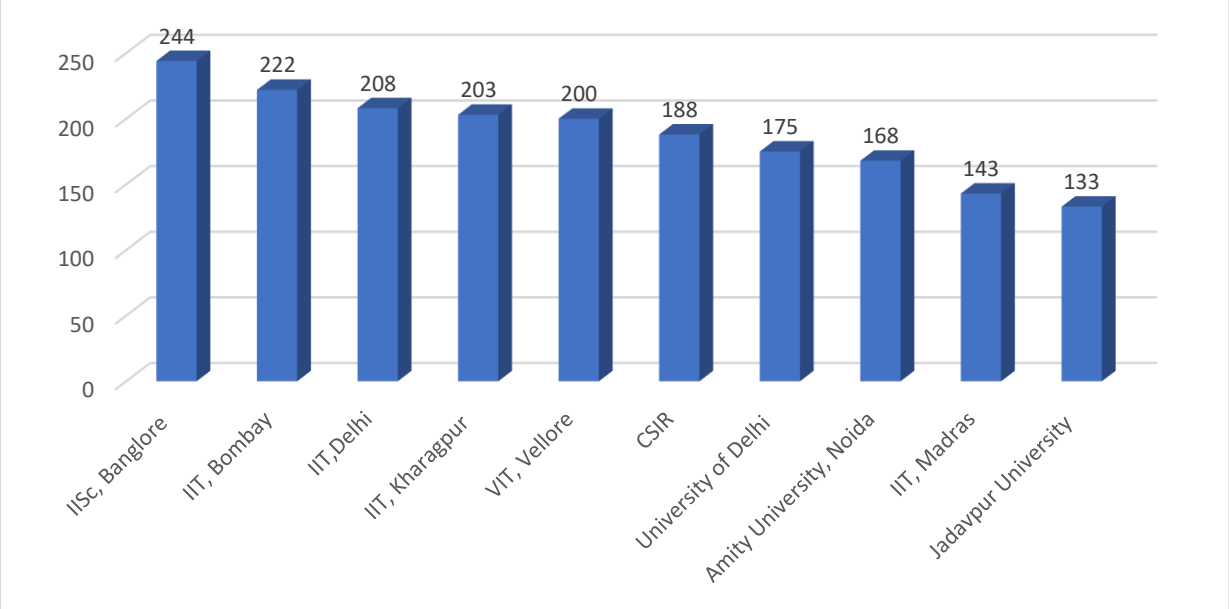

Figure 5: Top 10 Most Prolific Institution of Nanotechnology Research

6.7 Funding Agency

The figure 6 below depicts the top 10 funding agencies supporting research in Nanotechnology in SAARC nations in the period 1996 to 2020. It's a matter of pride for all Indians that a state agency, Department of Science and Technology, Govt. of Kerala is in the first position among the funding agencies in SAARC nationswith maximum number of 312 documents. This is followed by a statutory parent institution of India, University Grants Commission with 209 documents. Department of Science and Technology (DST), Govt. of India is a premier funding agency in India is in the third position with 202 documents.Among the other SAARC nation Bangladesh Council of Scientific and Industrial Research is also in

the top ten list with 181 documents. Two state departments Department of Biotechnology and DST, Govt. of West Bengal are also in the top ten list 107 and 75 documents respectively. An international body namely, National Research Foundation of Korea has 77 documents funded by it.

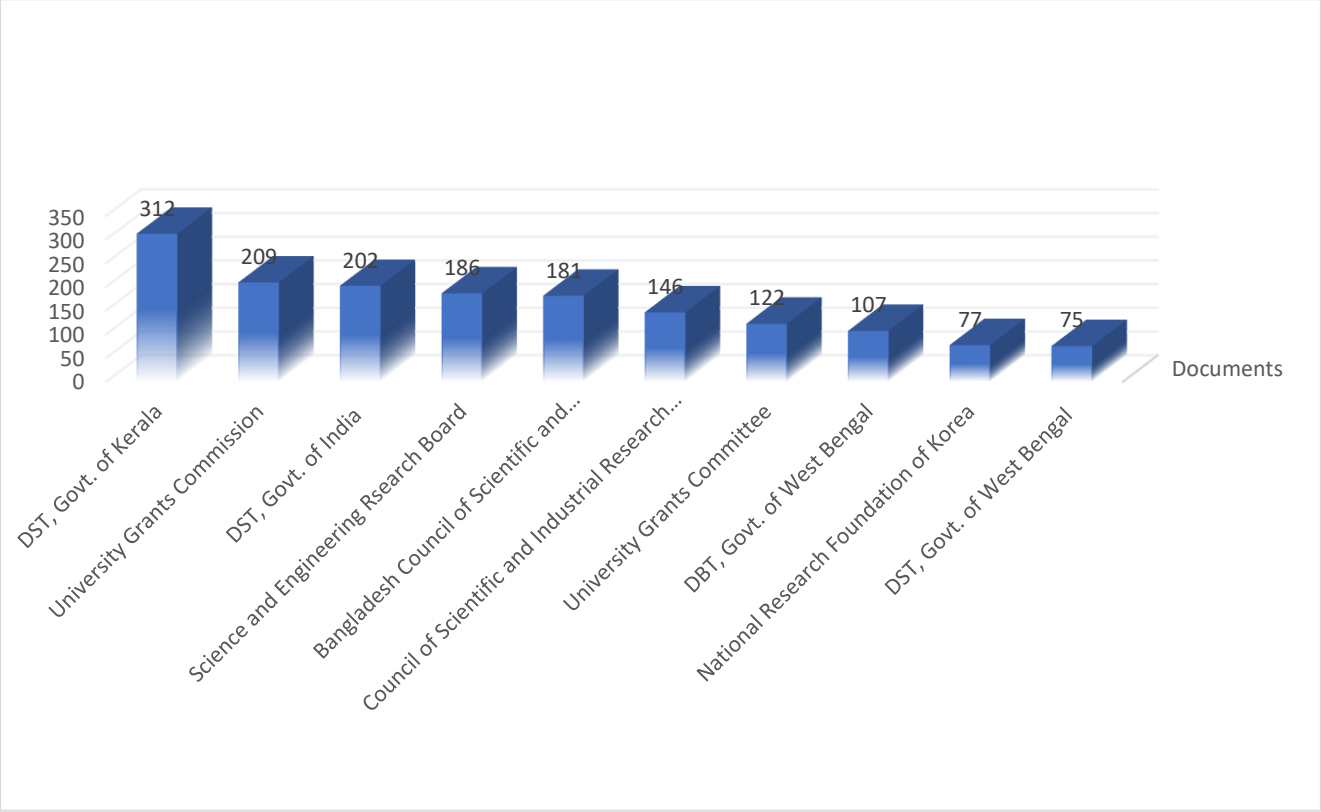

Figure 6: Top 10 Most Prominent Funding Agency for Nanotechnology Research

6.8 Geographical Distribution of Documents

Figure 7A depicts geographic visualization of number of documents and figure 7B shows the distribution of number of documents in Nanotechnology Research during 1996 to 2020 in SAARC nations. The figure 7 indicates the number of documents in the name of the SAARC nations. It is a matter of pride that India is in the top of the list with 11,207 documents with 1st rank and followed by our neighbour nation Pakistan with 817 documents in the 2ndrank this is followed by Bangladesh in the 3rd rank with 178 documents. This is followed by our neighbour in the South Sri Lanka in 4thrank with 58 documents and this is followed by Nepal and Afghanistan with 23 and 2 documents in 5th and 6th rank respectively. The SAARC nations Bhutan and Maldives has no records in their name in the database.

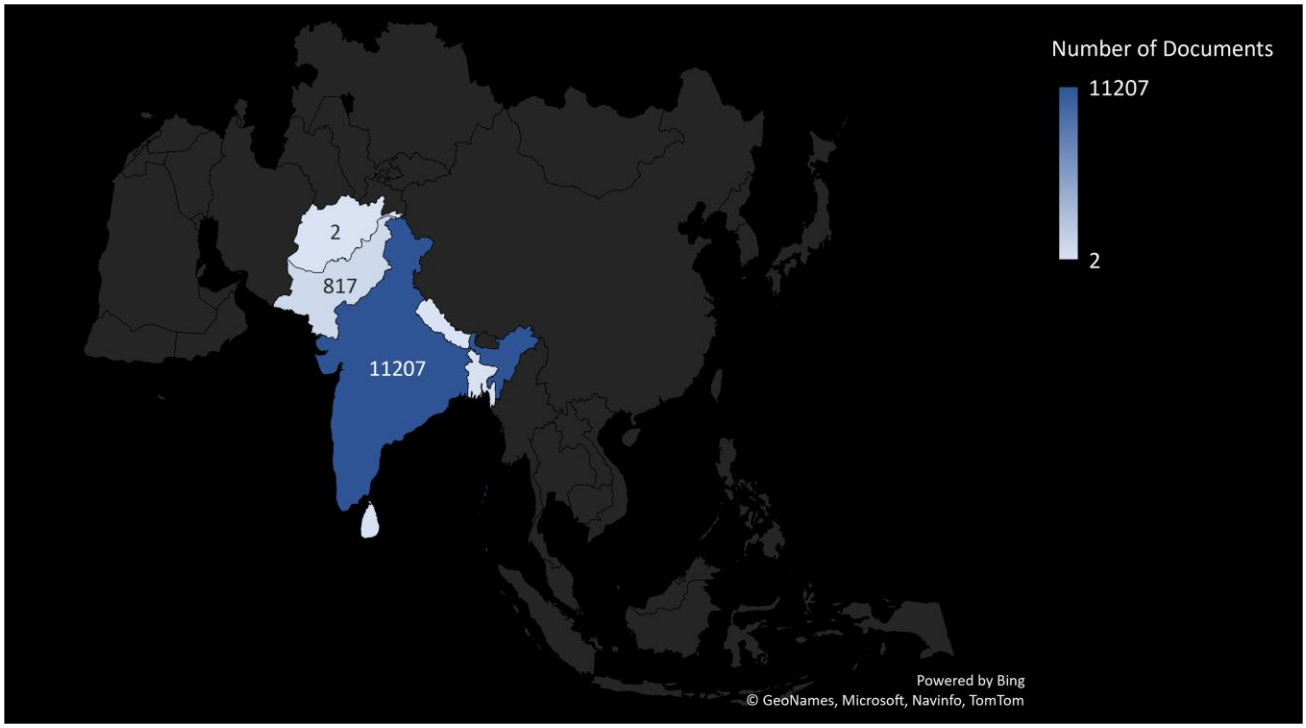

Figure 7A: Visualization of Geographical Distribution of Publications

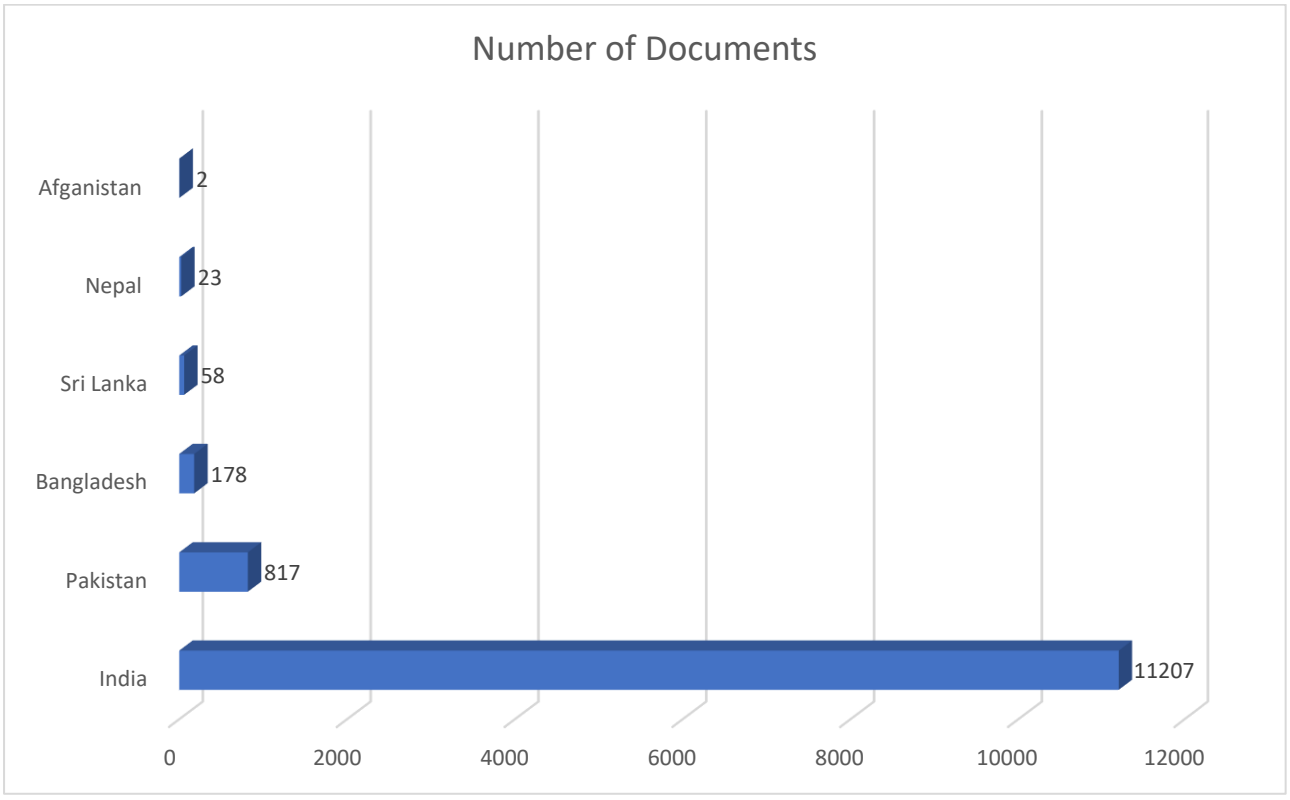

Figure 7B: Geographical Distribution of Documents

6.9 Document Form wise Distribution

The table 5 and figure 8 depicts the forms of published documents in Nanotechnology Research in the SAARC nations during the period 1996 to 2020. The observation of the figure it is clear that maximum of the documents published are in the form of articles (6118, 49.8%), this is followed by Conference paper (2546, 20.72%), Review (2104, 17.13%), Book Chapter (1098, 8.94%), Book (199, 1.62%). The least number of documents are Data Paper (4, 0.033%). There are 4 (0.033%) documents found to be undefined.

Table 5: Form of Documents

Document Type	Number of Documents	% of the total
Articles	6118	49.8005698
Conference Paper	2546	20.72446072
Review	2104	17.12657713
Book Chapter	1098	8.937728938
Book	199	1.61986162
Editorial	98	0.8
Letter	36	0.293
Short Survey	28	0.23
Erratum	24	0.2
Note	18	0.15
Retracted	8	0.065
Data Paper	4	0.033
Undefined	4	0.033
Total	**12285**	

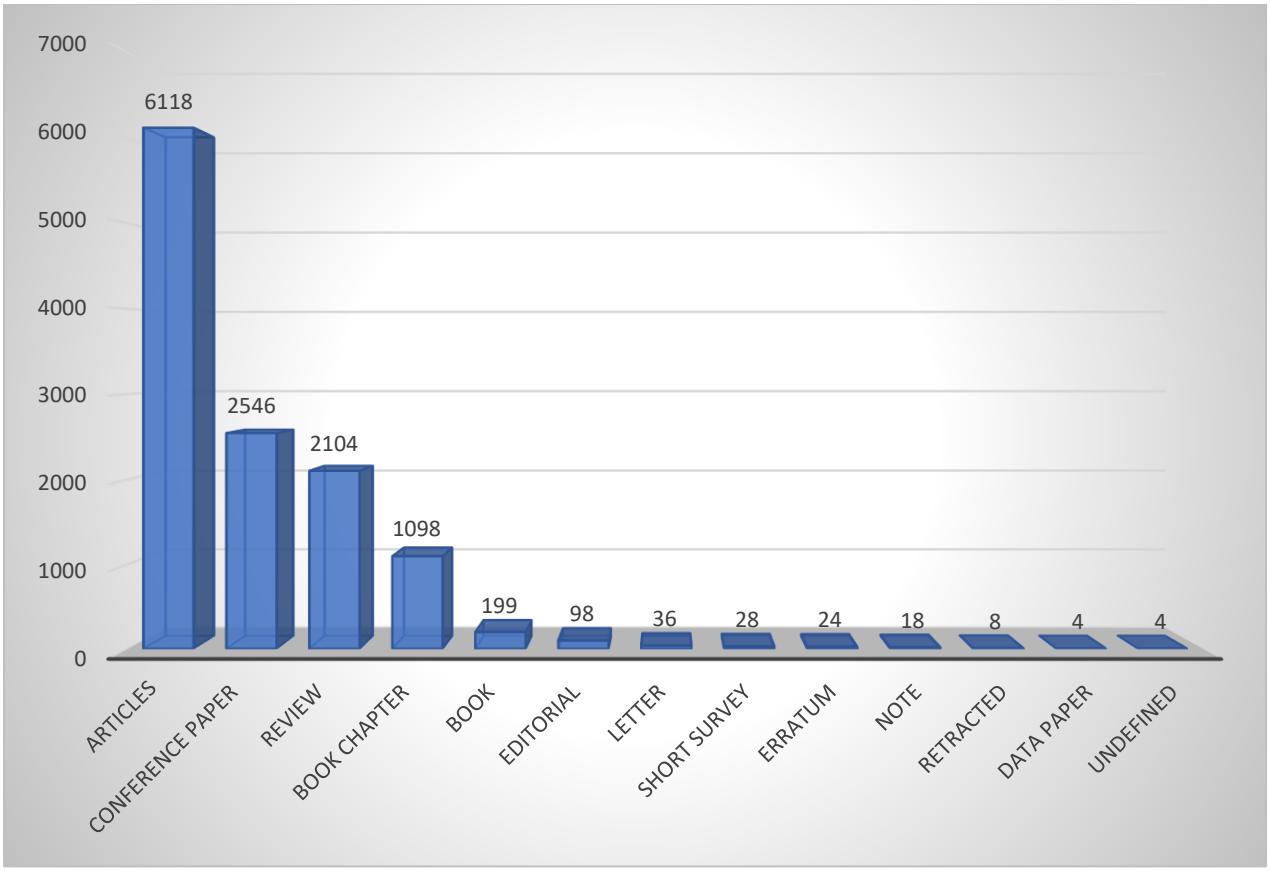

Figure 8: Document Form-wise Distribution

7. Conclusion

Nanotechnology,as the name suggest provides certain tools which are capable of monitoring at atomic level of matter. This is very useful in medical science. This is capable of monitoring individual cells at the level of individual molecules. Due to this characteristics researcher can investigate and monitor cellular functions and functions at the molecular level and change the systems that are deregulated due to a disease.

The study above reveals that highest number of articles are published in 2019 (1585, 0.123% of the total) and least number of articles are published in the year 1998 and 1999 (1, 0.00081% of the total). There is positive growth rate observed in the year 2000 to 2013 and from 2015 to 2019. Negative growth rate is observed in the year 1998, 2014 and 2020. Neutral growth rate is also observed in 1997 and 1999. The highest annual growth rate is observed for the year 2001 (333.33%) and lowest annual growth rate is observed in the year 1998 (-66.67%). The maximum number of publications are in the name of Rai, M (85 publications). It is observed that the number of authors observed are having much difference with number of authors expected, so it disobeys Lotka's Law of Productivity. In the top 10

most prolific authors the maximum number of articles (329) are published in Journal of Nano-Science and Nanotechnology and least in IeT Nanobiotechnology 66 articles.In the category of top 10 most prolific institution maximum number of articles are produced by Indian Institute of Science (IISc), Bangalore (244) and least by Jadavpur University, being a state university in India that it has got an international recognition in Nanotechnology Research with 133 publications in the tenth position in the list. Department of Science and Technology, Govt. of Kerala is in the first position among the funding agencies in SAARC nations in Nanotechnology Research with maximum number of 312 documents. Bangladesh Council of Scientific and Industrial Research is also in the top ten list with 181documents. India is in the top of the list with 11,207 documents with 1st rank and followed by our neighbour nation Pakistan with 817 documents in the 2nd rank this is followed by Bangladesh in the 3rd rank with 178 documents. Afghanistan has least count of 2 documents; Bhutan and Maldives have not been found in the Country list of the Scopus database in Nanotechnology Research during the period of study.

As Indian, it can be said as a matter of pride that India is in the top rankings among the SAARC nations in Nanotechnology Research during 1996 to 2020. Many Indian funding agencies have also their name in the top ten and in fact in the first ranking also in supporting Nanotechnology Research. Indian authors have also ranked first in the top ten categories of most prolific authors. Indian like Institutes of National Importance, Central Universities, Council of Scientific and Research, Private Universities and those too state universities are also doing well in the field of Nanotechnology Research. It is worth mentioning that globally India is in the third position in the share of articles related to Nanotechnology after China and U.S.A.

References

Bookstein, A. (1979). Explanations of the Bibliometric Distributions. *Collection Management, 3*(2-3), 151-62.

Chouhan , S. K. (2019). Scholarly output on drone research: A bibliometric study. *DESIDOC Journal of Library and Information Technology, 39*(2), 117-124. doi:10.14429/djlit.39.2.13970

Deka , B., & Hazarika , T. (2020). Scientometric Analysis of Nanotechnolgy Research with special reference to India(2008-17). *Library Philosophy and Practice (e-journal),* 4265. Retrieved from https://digitalcommons.unl.edu/libphilprac/4265/

Dutta , B., & Rath, D. (2013). Cosmology research in India: A scientometric study. *Library Philosophy and Practice(e-journal),* 996. Retrieved July 12, 2019, from http://digitalcommons.unl.edu/ libphilp

Gopal, M. R., & Sudhier, K. (2015). A quantitative analysis of bioinformatics literature in India. *Information Studies, 21*(2&3), 93-99.

Gopal, M. R., & Sudhier, K. (2017). Authorship Pattern and Collaborative Research in Indian Bioinformatics Research. *Journal of Indian Library Association, 53*(1), 15-23.

Kumar , R. S., & Kaliyaperumal , K. (2015). A scientometric analysis of mobile technology publications. *Scientometrics, 105*(2), 921-939.

Lotka , A. (1926). The Frequency Distribution of Scientific Productivity. *Journal of the Washington Academy of Sciences, 16*(12), 317-323.

Malik, B. A., Aftab, A., & Ali, P. N. (2019). Mapping of crowdsourcing research: A bibliometric analysis. *DESIDOC Journal of Library and Information Technology, 39*(1), 23-30. doi:10.14429/djlit.39.1.13630

Molatudi, M., Molotja, N., & Pouris, A. (2009). A bibliometric study of bioinformatics research in South Africa. *Scientometrics, 81*(1), 47-59.

Pandey, S., Verma , M. K., & Shukla , R. (2019). Bioinformatics Research in India during 2009-2018: A Scientometric Analysis. *Library Philosophy and Practice(e-journal)*.

Patra, S. K., & Chand , P. (2005). Biotechnology Research Profile of India. *Scientometrics, 63*(3), 583-597. doi:10.1007/s11192-005-0229-8

Sab, C., Kumar, P. D., & Biradar, B. (2018). Medicine Research in India: A Scientometric Assessment of Publications during 2009 – 2018. *Library Philosophy and Practice (e-journal)*.

Sudhier, K. G., & Dileepkumar , V. (2020). Scientometric Profile of Biochemistry research in India: A Study based on Web of Science. *DESIDOC Journal of Library & Information Technology, 40*(1), 388-396. Retrieved from https://doi.org/10.14429/djlit.40.01.14998

Sudhier, K. P. (2013). Lotka's Law and Pattern of Author Productivity in the Area of Physics Research. *DESIDOC Journal of Library & Information Technology, 33*(6), 457-464.

Sudhier, K., & Jahina , S. R. (2020). Scientometrics of Indian Bioinformatics Research Output: A Study on Web of Science. *Library Philosophy and Practice (e-journal)*, 4407. Retrieved from https://digitalcommons.unl.edu/libphilprac/4407

Wolfgang, G., Frizo, J., & Bart, T. (2009). A Comparative analysis of publication activity and citation impact based on the core literature in bioinformatics. *Scientometrics, 79*(1), 109-209.