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Publications Output of the Indian Association for the Cultivation of Science during 2008-2017: A Scientometric Assessment

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ABSTRACT

The present scientometric study assesses the publication output of the scientists of Indian Association for the Cultivation of Science (IACS) during 2008 to 2017 as reflected in the Web of Science database to figure out the research performance, scholarly communication behaviour and its citation impact. The scientists of IACS contribute total 4,304 research articles including 22.58 percent international collaborated articles. Further, the publications have been evaluated in terms of year, types of collaboration, authorship pattern, source journals, impact factor, collaborating institutions, collaborating countries and citations. It is found that majority of the published articles are produced by three authored and the international collaborated articles which receive wider citation impact. The developed countries like USA, Japan, Germany and England are found as the most favoured countries by the scientists of IACS for research collaboration and the Journal of Physical Chemistry C shares maximum research articles. Further, Pareto's 80/20 principle has also been applied to examine the scattering of journals as well as articles and the VOS viewer software has been used for mapping the network of collaborating countries.

Keywords: Publications output; Scientometric study; Indian association for the cultivation of science; Citation impact.

1. INTRODUCTION

The Indian Association for the Cultivation of Science (IACS) is the oldest scientific institutions in Asia. Dr Mahendra Lal Sircar, a medical practitioner founded the IACS in 1876 at Kolkata primarily as a science teaching institute and later on it slowly emerged as a premier research institute of the country[1]. Sir C.V. Raman made his historic discovery of 'Raman Effect' at IACS. It is an autonomous research institution funded by the Department of Science and Technology (DST) of the Government of India and by the Government of West Bengal[1]. In May 2018, the IACS has been conferred as a 'Deemed University' status under the de novo category of the University Grants Commission (UGC) Act, 1956 for offering degrees in emerging areas of basic and applied sciences. Last year, IACS launched Integrated Bachelor's & Master's Program and Master's/Integrated Master's-PhD programs in various areas of Science[2]. The Nature Index pointed out[3] that the institute is one of the top-ten Indian institutions in the context of well-recognised global institutions.

Scientometric assessment evaluates scientific research publications as a proxy for research. Hence, in this context, the present study is an attempt to identify the research performance and scholarly impact of the scientists of IACS over the last decade by analysing the scholarly publications.

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2. LITERATURE REVIEW

Literature review highlights the earlier studies on research productivity and assessment of institutional performance in India. For instance,

Nagarkar with others[4-5] in their two studies identified the research productivity of the SP Pune University (SPPU) in Life Sciences and Physics discipline and revealed that the faculty members published 690 and 1629 publication respectively. Both the papers interpreted the data in terms of chronological order, collaborations, preferred journals, citations etc.

In another study, Shivaram[6], *et al.* examined the 1002 research paper of CSIR- National Aerospace Laboratories (NAL) during 2005-2014 and reported that the NAL share 21 per cent publications of the aerospace literature in India.

Mondal and Raychoudhury[7-8] also evaluated the research outcomes of two prestigious institutions of West Bengal i.e. Jadavpur University (JU) and Saha Institute of Nuclear Physics (SINP) as reflected in the Web of Science (WoS) database. The faculty members of the institutions produced 6,895 article and 3,694 article respectively while the internationally collaborated articles occupied 21.06 per cent and 41.20 per cent individually.

Mukherjee[9] pointed out the research contributions of CSIR Laboratories, India during 2010 to 2015 and revealed that the Indian Institute Chemical Technology, Hyderabad has contributed highest of 3821 article followed by the National Chemical Laboratory, Pune with 2576 article.

Maurya[10], *et al*. assessed the 404 scholarly communications of Mizoram University during 2007-2016 and interpreted the data based on year, citations, prolific contributors, collaboration, authorship pattern, productive areas, favoured journals, funding agencies etc.

3. OBJECTIVES OF THE STUDY

The present study examines the research performance, publication behaviour and citations impact of the scholarly communications of the scientists of IACS. The main objectives are as follows.

- Demonstrate year wise distribution and growth of publications output
- Depict impact of research collaboration trend and authorship pattern
- Illustrate distribution of journals and articles by impact factor
- Assess publications pattern and source journals
- Reveal leading collaborative institutions and countries
- Report citations details.

4. DATA SOURCE, LIMITATIONS AND METHODOLOGY

The present study is restricted to only research 'article' publications of the scientists of IACS during the period of 2008 to 2017. For this purpose, the Web of Science (WoS) core collection database has been consulted and searched during the first week of March, 2019. The Thomson Reuters 'Journal Citation Report-2018' was also scanned to identity the impact factor (IF) of source journals and the annual report of the institute was also intensely studied.

The following search strategies are applied to retrieve the required data.

- Organisation-enhanced: Indian Association for the Cultivation of Science (IACS)-Jadavpur (selected from index)
- Time span : 2008-2017
- Refined by: Document Types: Article

The query results 4,479 record which include article (4,304), review (85), proceedings paper (81), meeting abstract (36), correction (25), editorial material (22), biographical item (3), letter (3), and book chapter (2) etc. Then, from the total search results only 4,304 article have been selected and refined to get the bibliographical details for further analysis. Later on, the raw data are exported into a text file format from WoS database and organised to spreadsheet for further analysis. Tables and figures are also used to analyse and interpret the data.

5. RESULTS

The details of 4304 article have been interpreted on the aspects of different criteria like year, collaboration, authorship, impact factor, journal, collaborative institutions, country and citations.

5.1 Annual Distribution and Growth of Publications Output

Table 1 presents the year wise distribution of publications output. In last decade, the scientists of IACS publish total 4304 article including 972 internationally collaborated article (22.58 %). Out of total articles, maximum of 487 articles (11.31 %) publish in the year 2014 closely followed by the year 2012 with 470 articles (10.92 %). Overall, fluctuating trend has been seen in the publications output of IACS with Compound Annual Growth Rate of 0.864 per cent whereas declining trend has been found in the international collaboration output.

Table 1. Distribution of publications growth by year

Year	No of Articles	Percentage	CAGR %	ICP	% ICP
2008	385	8.94	-	119	30.91
2009	407	9.45	5.71	104	25.55
2010	413	9.6	1.47	103	24.94
2011	451	10.48	9.2	106	23.50
2012	470	10.92	4.21	104	22.12
2013	460	10.68	-2.13	78	16.95
2014	487	11.31	5.87	83	17.04
2015	399	9.27	-18.07	83	20.80
2016	416	9.66	4.26	94	22.6
2017	416	9.66	0	98	23.56
Total	4304	100	0.864	972	22.58

CAGR=Compound Annual Growth Rate; ICP=International collaborative publications

The mathematical formula for calculation of Compound Annual Growth Rate (CAGR) is mentioned as follows[11]:

$$CAGR = \left(\frac{EndingValue}{BeginingValue} \right)^{\left(\frac{1}{NumberofYears} \right)} - 1$$

CAGR%= CAGR × 100

5.2 Impact of Research Collaboration Trend of IACS

Table 2 represents the year wise collaboration trend of the scientists of IACS and its citation impact. International collaborated articles (ICA) include those articles where at least one author appears from foreign country whereas domestic collaborated articles (DCA) consider only Indian authors' paper. The scientists of IACS collaborate with national institutions and produce total 3332 article (77.42 %) which also receive avg. citations of 16.55 per paper. Similarly, the scientists also contribute 972 international collaborated articles (ICA) (22.58 %) with 18.91 avg. citations per paper. During the period of 2012 to 2013, maximum of 748 domestic collaborated articles (22.45 %) have been published while highest number 223 international collaborated articles (22.94 %) have been produced during 2008 to 2009.

Table 2. Collaboration output of the IACS and its citation impact

Collaboration Types	Collaboration output, share and impact	Year					Total
		2008-09	2010-11	2012-13	2014-15	2016-17	
Domestic Collaboration	DCA	569	655	748	720	640	3332
	% of DCA	17.07	19.65	22.45	21.60	19.20	100
	Avg. citations per paper	22.32	22.20	17.17	14.3	6.85	16.55
International Collaboration	ICA	223	209	182	166	192	972
	% of ICA	22.94	21.50	18.72	17.08	19.75	100
	Avg. citations per paper	21.9	25.49	20.6	18.33	7.17	18.91

DCA= Domestic collaborated articles; ICA= International collaborated articles

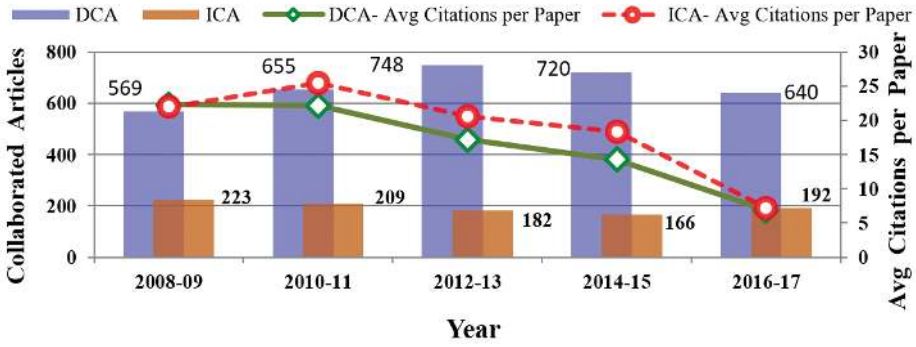

Figure 1. Collaboration trend and citation impact of the IACS publications.

Table 3. Distribution of authorship pattern and citation impact

Authorship	Articles	% articles	Times cited	Avg. Citations/ article	h-index	AC_{50}
1	62	1.44	358	5.77	10	1
2	840	19.51	13227	15.74	53	58
3	1157	26.88	20317	17.56	**60**	**86**
4	982	22.81	17467	17.79	52	60
5	520	12.08	8572	16.48	42	29
6	348	8.08	5949	17.1	38	21
7	180	4.18	3726	**20.7**	33	13
8	88	2.04	1536	17.45	23	7
9	59	1.37	1120	19	20	8
10	23	0.53	451	19.61	11	2
>>10	45	1.04	803	17.84	17	3
Total=	4304	100	73526	17.08	87	288

AC_{50}= Number of articles having at least 50 or more citations

5.3 Collaborative Authorship Pattern and Citation Impact

Table 3 explores the data related to authorship pattern of the scientists of IACS and its citation impact. Three authorship articles share highest number of 1157 article (26.88 %) which get maximum h-index of 60 and also 86 articles receive at least 50 or more citations. This is followed by four-authored with 982 article (22.81 %) and two-authored with 840 articles (19.51 %). Conversely, 180 articles by seven-authored receive maximum of 20.7 avg. citations per article while single authored articles receive least citations impact of 5.77 avg. citations per article with lesser h-index of 10 and AC_{50} of 1.

5.4 Impact Factor wise Distribution of Journals and Articles

Table 4 and Fig. 2 examine the distribution of journals and articles according to impact factors (IF). Highest number of 1246 article (29 %) publish in 104 journal (22.70 %) having IF range of ≥2 - <3 followed by 860 article (20 %) in 81 journal (17.68 %) having IF range of ≥ 3- <4 and 632 (14.7 %) articles in 36 journals (7.86 %) with IF range of ≥ 4- <5. Further, the 111 articles publish in 19 journals having IF range of ≥ 10. The average IF per article (i.e. available 4246 papers) is 3.798.

5.5 Publications Trend

Table 5 demonstrates the data related to publication pattern, scattering of journals and their share of the total number of articles. Highest number of 187 journal (40.83 %) shares 187 article (4.34 %) whereas only 5 most favoured journals (1.1 %) contribute 637 article (14.8 %). It is also noticed from the table that top

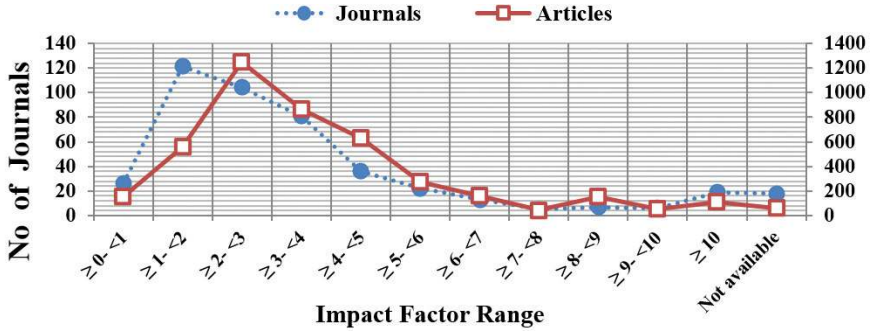

Figure 2. Impact factor range wise distribution of journals and articles.

Table 4. Distribution of journals and articles by impact Factors

IF Range (JCR, 2018)	No. of journals	% Journals	No. of articles	% articles
≥ 0-<1	26	5.67	154	3.58
≥ 1-<2	121	26.42	560	13.01
≥ 2-<3	104	22.70	1246	29
≥ 3-<4	81	17.68	860	20
≥ 4-<5	36	7.86	632	14.7
≥ 5-<6	22	4.80	272	6.32
≥ 6-<7	13	2.84	161	3.74
≥ 7-<8	5	1.1	43	0.1
≥ 8-<9	7	1.53	152	3.53
≥ 9-<10	6	1.31	55	1.27
≥ 10	19	4.15	111	2.58
Not available	18	3.93	58	1.34
Total=	458	100	4304	100
Avg IF/ Article=			3.798	

Table 5. Publications pattern by journals

Articles publish in journals	Journals	% Journals	Articles	% Articles
1	187	40.83	187	4.34
2-5	140	30.56	407	9.45
6-10	35	7.64	263	6.11
11-20	41	8.95	609	14.15
21-30	17	3.71	414	9.62
31-50	17	3.71	682	15.84
51-70	9	1.96	549	12.75
71-100	7	1.53	556	12.92
More than 100	5	1.1	637	14.8
Total=	458	100	4304	100

21 preferred journal (4.58 %) contribute more than 50 article and altogether share1742 articles which constitute 40.47%.

5.5.1 Application of the 80/20 Rule on Journal-Article Data

The "80/20 Law" is nowadays called "Pareto's law" states that generally 80 per cent of all effects result from 20 per cent of all causes[12]. The rule has been widely accepted in multi-disciplinary areas to indicate cause-effect relationship.

Here, the 80/20 rule is applied to the data of source journals and their share of the contributed articles. According to the law, 20 per cent most productive journals contain 80 per cent of articles and 80 per cent journals contain 20 per cent articles.

In the present study, out of total 458 journals, 92 (20 %) journal contribute 3403 article (79.06 %) while the rest of the 80 per cent journals i.e. 366 share 901 article (20.93 %). The observed data is almost similar to expected data.

The percentage of error in 20 per cent journals output is= [(3443 – 3403) ×100/ 3403] = 1.17%.

Hence, the percentage of error is nominal and the data set fits 80/20 effect.

Table 6. Distribution of 80:20 effects in sources journals and articles

80/20 rule	No. of journals	No. of articles			
		Observed	%	Expected	%
20 % of journals	92	3403	79.06	3443	80
80 % of journals	366	901	20.93	861	20

5.6 Preferred Source Journals for Scholarly Communications

Table 7 demonstrates the ranking of preferred journals by the scientists of IACS. Out of top 12 source journals, the *Journal of Physical Chemistry C* with IF of 4.484 publishes maximum of 159 article followed by the *RSC Advances* with 134 article and the *Physical Review B* journal with 129 article. Alternatively, 159 articles of the *Journal of Physical Chemistry C* receive maximum citations impact with 33.56 avg. citations per article, h-index of 37 and also 8 article receive minimum 100 or more citations.

5.7 Leading Collaborative Institutions

Table 8 reveals the leading collaborating institutions with the scientists of IACS. The Jadavpur University contribute maximum of 204 collaborated articles which also get maximum h-index of 29 followed by the University of Calcutta with 163 article and the Indian Institute of Science with 116 articles. Alternatively, the 116 collaborated articles of the Indian Institute of Science also receive maximum of 20.61 avg. citations per article while the 79 article of the Kalyani

Table 7. Top 12 preferred source journals of the scientists of IACS

Journals with Impact Factor, 2018	No of Articles	Sum of times cited	Avg. citations/ article	h-index	AC_{100}
Journal of Physical Chemistry C, 4.484	159	5337	**33.56**	**37**	**08**
RSC Advances, 2.936	134	1590	11.86	21	0
Physical Review B, 3.813	129	1913	14.83	23	1
Chemical Communications, 6.29	108	3275	30.32	33	3
Journal of Applied Physics, 2.176	107	1119	10.46	20	0
Inorganic Chemistry, 4.7	92	2097	22.8	27	0
Chemistry –a European Journal, 5.16	85	2097	24.67	27	3
Physical Review D, 4.394	79	989	12.52	18	0
Journal of Physical Chemistry B, 3.146	78	1802	23.10	26	1
Journal of Chemical Physics, 2.843	76	1054	13.87	18	0
ACS Applied Materials & Interfaces, 8.097	73	2384	32.65	30	2
Physical Chemistry Chemical Physics, 3.906	73	853	11.68	17	0

AC_{100}= Number of articles having at least 100 or more citations

Table 8. Top 10 collaborating institutions

Collaborating Institutions	Country	Articles	Times cited	Avg. Citations per article	h-index
Jadavpur University, Kolkata	India	204	3003	14.72	**29**
University of Calcutta, Kolkata	India	163	2219	13.61	26
Indian Institute of Science, Bangalore	India	116	2391	**20.61**	23
University of Burdwan, Burdwan	India	93	1433	15.41	19
Saha Institute of Nuclear Physics, Kolkata	India	88	1008	11.45	19
Kalyani University, Kalyani	India	79	1422	18	21
Bhabha Atomic Research Centre, Mumbai	India	64	1095	17.11	19
SN Bose National Centre for Basic Sciences, Kolkata	India	59	594	10.07	14
Indian Institute of Engineering Science and Technology, Shibpur	India	57	792	13.89	17
University of Reading	England	57	630	11.05	14

University occupy the 2nd position by sharing the avg. citations of 18 per article. Besides, it is seen from the table that out of top 10 leading collaborating institutions, 9 institutions belong to the home country i.e. India while the rest one institution i.e. the University of Reading is from England.

5.8 Country-wise Distribution of Collaborating Articles

Country wise research collaboration output is depicted in Table 9. The scientists of IACS collaborate with the scientists of 54 countries. Out of these, USA leads the table with 202 article which also receive maximum h-index of 33 followed by Japan with 128 article and Germany with 127 article. Conversely, 78 collaborated articles with Italy receive highest of 31.46 avg. citations per article followed by 25 collaborated articles of Singapore with avg. citations of 30.56. Figure 3 sketches the map of top 20 collaborating countries using VOSviewer software.

5.9 Citations Statistics

Table 10 highlights the citation details of the publications of the scientists of IACS. During the spanning period of 2008

Table 9. Country wise break-up of collaboration output of IACS

Country	Articles	Times cited	Avg. Citations per article	h-index
USA	202	4568	22.61	33
Japan	128	2803	21.9	29
Germany	127	2017	15.88	23
England	116	1645	14.18	23
Italy	78	2454	31.46	21
France	74	1158	15.65	20
Spain	56	1426	25.46	22
Taiwan	43	457	10.63	14
Israel	35	619	17.69	12
South Korea	34	702	20.65	15
Sweden	34	458	13.47	14
Canada	29	416	14.34	11
Portugal	28	428	15.29	12
Poland	26	210	8.08	9
Singapore	25	764	30.56	15
Others (39 Countries)	3451	58013	16.81	83

Table 10. Citation report

Citation details	Results
Total articles	4304
Sum of times cited	73526
Sum of times cited without self-citations	63783
Citing articles	51546
Citing articles without self-citations	48637
Avg. citations per item	17.08
h-index	87
AC_{100}	62
Not cited	200

AC_{100}= *Number of articles having at least 100 or more citations*

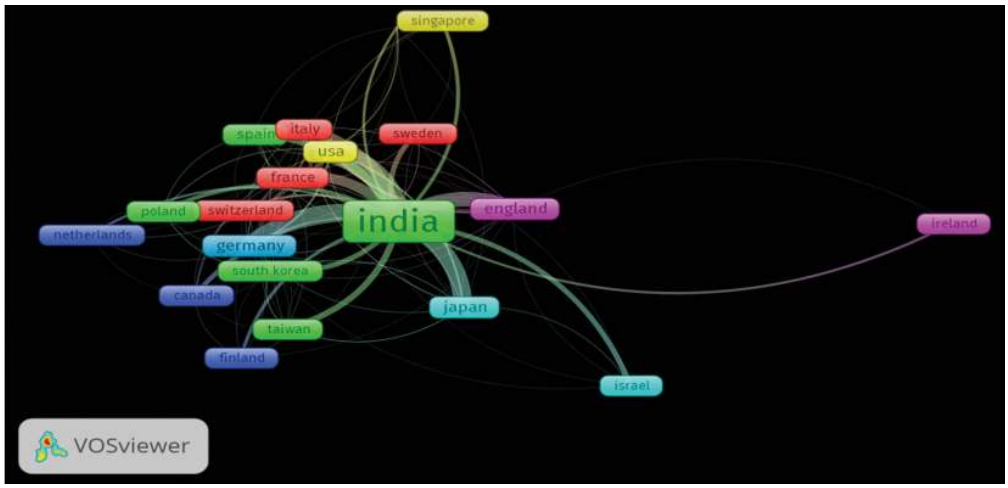

Figure 3. Mapping of top 20 collaborating countries with India (IACS)

to 2017, total 4304 article have been published having 73,526 citation, 51,546 citing articles and 17.08 avg. citations per paper. Further, the h-index is 87 and 62 articles receive minimum 100 citation. Interestingly, 200 article remain uncited.

6. CONCLUSIONS

During the last decade, the scientists of IACS contribute total 4304 scientific research articles having 17.08 avg. citations per paper and the international collaborated articles (22.58 %) attract greater citation impact as compared to domestic collaborated articles (77.42 %). However, the proportion of international research collaboration is gradually decreasing while the domestic collaboration trend has been increasing. Hence, the scientists of IACS should give more emphasis and endeavour towards international collaboration. Concurrently, maximum of the top collaborating institutions belong to the home country, so there is a need to increase collaboration with reputed national institutions of foreign countries too. The developed countries like USA, Japan, Germany and England are found to be the most collaborated foreign countries for research.

Further, the authorship pattern of the articles also exhibits that the multi-authorship efforts are predominant and attract higher citations impact whereas the single authored articles receive least citations impact. In addition, the research papers have been published in selective global level reputed journals with high impact factor and the average IF per article is 3.798. The *Journal of Physical Chemistry C* has been found as the most productive and cited journal. Besides, it is interesting to note that the scattering of source journals and articles also confirm the Pareto's 80/20 rule.

These finding will encourage Indian national higher education as well as research institutions to go for more international collaborative works for wider research impact and also to strengthen our country's research infrastructure and capability. The authority of the institute has already implemented online institutional repository system to archive and disseminate the intellectual scholarly content in the open access environment but it needs to be updated regularly for relevancy and more comprehensiveness. Hope the 'Deemed

University' status will boost the institute and the institute will continue the legacy of scientific research for the benefit of the society as well as Indians, as dreamt by Dr Sircar, the founder of the institute.

REFERENCES

1. www.iacs.res.in/old/introduction.html (accessed on 23 March 2019).
2. www.iacs.res.in/upload_files/newsletter/1528454202_Admission_Notice.pdf (accessed on 23 March 2019).
3. www.natureindex.com/custom-reports/indian-science-ascending/top-institutes-an-international-comparison (accessed on 03 March 2019).
4. Nagarkar, S.; Veer, C. & Kumbhar, R. Bibliometric Analysis of papers published by faculty of life science departments of Savitribai Phule Pune University during 1999-2013. *DESIDOC J. Lib. Inf. Technol.*, 2015, **35**(5), 368-375.
5. Nagarkar, S. & Kengar, M. Analysis of physics research output of SP Pune University during the period 1990-2014. *Annals Lib. Inf. Stud.*, 2017, **64**(2), 106-112.
6. Shivaram, B.S.; Sahu, S.R.; Dey, S.R. & Ramesha, B. A critical analysis of scientific productivity of an institute, CSIR-NAL. *SRELS J. Inf. Manage.*, 2016, **53**(2): 129-132.
7. Mondal, D. & Raychoudhury, N. Contribution of Jadavpur University in S&T as reflected in WoS database during 2006-2015. *IASLIC Bulletin*, 2017, **62**(3), 161-172.
8. Mondal, D. & Raychoudhury, N. Research productivity of saha institute of nuclear physics (SINP), India with special reference to international collaborative experimental consortia. *Lib. Philos. Pract. (e-journal),* 2018. http://digitalcommons.unl.edu/libphilprac/1863 (accessed on 21 February 2019).
9. Mukherjee, B. Research in Indian CSIR laboratories: A bibliometric study. *SRELS J. Inf. Manage.*, 2017, **54**(4), 165-174. http://www.srels.org/index.php/sjim/article/view/118103 (accessed on 10 March 2019).
10. Maurya, S.K.; Shukla, A. & Ngurtinkhuma, R.K. Scholarly communications of Mizoram University on Web of Science in global perspective: A scientometric assessment. *Libr. Philos. Pract. (e-journal)*. 2018. http://digitalcommons.unl.edu/libphilprac/1857 (accessed on 21 February 2019).
11. www.investopedia.com/terms/c/cagr.asp (accessed on 11 March 2019).
12. Hardy, M. Pareto's Law. *Math. Intell.*, 2010, **32**(3), 38-43. doi: 10.1007/s00283-010-9159-2.

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Contribution in the current study: He suggested, edited and improved the contents of the manuscript to shape it in the final approval version.