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Top 10 Indian Academic/Research Organizations: A Scientometric Analysis of Research in Biotechnology

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Abstract

Scientometric study is an effective assessment tool for ongoing researches in a given field. It applies mathematical and statistical methods to study the use of documents and patterns of publication. Present work attempts to describe the patterns of publication by top ten Indian Academic/Research Organizations in the field of Biotechnology. Overall, 5423 articles were related to the field in Scopus database during 2001-2016. The applied scientometric tools are Collaboration Coefficient, Co-authorship Index and Activity Index to study the trend of authorship and collaborative research activities in the given domain. The activity Index formula has been modified for the mapping of Institute data. The most preferred country for international collaboration was United States.

Keywords

Scientometric Analysis, Collaboration Coefficient,Co-authorship Index, Domestic Collaborative index, International Collaborative index, Biotechnology, Activity index.

1. Introduction

Biotechnology is an interdisciplinary field that combines biological sciences with the engineering technologies to improve human life. Biotechnology has been significant in the field of health care, agriculture and environment.The importance of this field is recognized world over due to its unlimited potential to serve and benefit humanity. India has been actively engaged in

researches related to biotechnology. Department of Biotechnology, Government of India supports the research and development activities in biotechnology.[1]

Collaboration among scientific community facilitates exchange of scientific dialogue; hence, to learn new information and approaches that eventually accelerates the process of research. A systematic analysis of the scientific trend and collaboration network is beneficial for the researchers exploring avenues for collaboration.Collaboration may occur at different levels i.e. between individuals, groups, institutions, or nations. Scientometric study facilitates analysis of an individual entity with respect to their contribution and influence in a given field of knowledge. It provides an approach for situating a country concerning the world, an institution with a country and even individual scientists about their peers [
YAO (QIANG) et.al. (2014)].

The Higher Education Institutions whose basic aim is the contribution of scientific developments and providing education have been showing an increasing interest in the evaluation of productivity and quality. In fact, productivity and quality assessment are essential for all type of organizations. This evaluation helps an organization to set short and long term goals by defining the current situations, futuristic expectations and roadmap. The studies on evaluation of academic productivity and quality have led to the development of new academic fields such as Bibliometrics, Scientometrics and Informatics (this is not correct). Consequently, new academic journals specializing in these disciplines have emerged.

This study reveals the author contribution pattern of Indian Academic/Research Organizations. The activity index is calculated for each individual Research Institute; however, the focus is on studying the status of biotechnology research against all Academic/Research Institute. Year wise publication distribution growth rate enumerates the output of a particular organization in a given year. The collaboration coefficient tool is used to evaluate the measurement of single and multi-author collaborative research pattern. The authorship pattern is an importance aspect of any bibliometric study. It helps to gather the current status and the future scenario of biotechnology research within the vicinity of top ten Indian Research Organizations.

2. Review of Literature

R, Parameswaran[2] studied the growth pattern of the research contribution by the authors of Anna University during 1980-2013 and observed gradual growth of publications. Most of the research output by authors were in collaboration with other scholars of the parent institution as well as from others.

R. Balasubramani [3] reported a slower growth of publications in his study on growth of research contribution by the scientists of Banaras Hindu University during 2000 - 2011. He also reported on the collaboration pattern of the scientists.

Nabi Hasan and Mukhtar Singh [4] evaluated the research output of five top ranked Indian Institutes of Technology (IITs). A scientometric study of research papers presented in the study by year-wise distribution of publications among IITs opposite to total Indian research output, the degree of collaborations,Institutional distribution with other countries and with the institutions from India.

Dilruba Mahbuba and Ronald Rousseau [5] compared the International Centre for Diarrheal Disease Research in Bangladesh (ICDDRB) and the National Institute of Cholera and Enteric Diseases (NICED) in India, during the period 1979-2008. The analysis presents the types of publications, international collaboration with other countries, top scientists and most cited articles co-authored by scientists from these institutions highlighted.

Mahadeva S.[6] analyzed research growth at Indian Institute of Technology, Kharagpur. Analysis of Growth pattern of research publications of Indian Institute of Technology is done along with a study of author productivity.

Singh, V.K. [7] studied the research publications of Indian Institute of Technology, Guwahati (IITG). The study involved computation of collaboration pattern at different levels such as author, institution.

M. Prakash[8] measures the performance of Indian biotechnology research based on publishing trend, authorship pattern, the degree of collaboration, preferred journals by the scientists and citations. The study shows an upward trend in some collaborated papers.

Patra, S.K. and Prakash, C. [9] explores Indian biotechnology research pattern with the application of Lotka's law and Bradford law of scattering. The study also shows the core journals, scattering of literature along with most active authors, institutions and statewise distributions of Indian Biotechnology research output.

3. Objective of Study

1. To know year wise comparative publication distribution of literature.
2. To measure the collaborative coefficient and Co-authorship Index of the Institute.
3. To find out nature of Domestic and international collaboration pattern.
4. To measure an Activity Index of the individual Institute.
5. To know the highly cited paper and author of the Institute.
6. To know the ratio of government and private Institute collaboration.

4. Scope and Limitation

The study covers literature published from 2001 to 2016, both years inclusive. Records during the term of study have been downloaded exclusively from SCOPUS online database. Generalizationis based on the downloaded data within the time span of sixteen years. Any later proposal for the inclusion or exclusion of/from these institutions and possible change of nomenclature after 2016 is not taken into the consideration of this study. Overall 5423 documents related to the study is used. The subfields of the biotechnology are used to make search string; it is used to download data from Scopus database. Define search string separately downloads the Institute data.

5. Data and Methodology

SCOPUS has been taken for data the collection of. **Scopus** database contains abstracts and citations for peer reviewed journal articles. To extract the record of Biotechnology literature for the study, following search string has been adopted (Biotechnology OR biomedicine OR bioremediation OR biosynthesis OR bioinformatics OR bioengineering OR biogenetics OR biomedicine OR cell biology OR biofuels). The search yielded 5423 records for the period of study 2001-2016. These records provided bibliographical details such as Title, Authors, Source, Year, Abstract, Affiliation, Language, Document Type, etc. The data extracted from the database has been processed and analyzed using Microsoft Excel. The extracted data were administrated to the Scientometrics tools and techniques to ascertain the fulfilment of stated objectives and its measurement methods discussed below.

5.1 Collaborative Coefficient (CC)

Defined by Ajiferuke et al., Collaborative Coefficient measures collaboration in research. It reflects both the mean number of authors per paper as well as the proportion of multi-authored papers [.)s

SAVANUR (KIRAN) AND SRIKANTH]. It was based on fractional productivity defined by Price and Beaver [11]. It is computed using following formula.

$$CC = 1 - \sum_{j=1}^{k} \left(\frac{1}{j}\right) fj/N$$

Here, *fj*denotes the number of *j* authored research papers*;*

N indicates a total number of research papers published,

*k*is the greatest number of authors per paper.

CC indicates zero when single-authored papers dominate and to 1-1/*j* as *j*-authored papers dominate. This method shows the result that higher value of CC, related to higher rate of proxy to multi or mega authored articles.

5.2 Co-Authorship Index (CAI)

Given by Garg &Padhi[12], Co-Authorship Index is used to study the change in Co-Authorship pattern during the study period. The methodology is similar to one suggested by Price [13] and used to calculate Activity Index (AI) as proposed by Frame [14] and elaborated by Schubert and Braun [15].

CAI = {(*Nij*/*Nio*)/(*Noj/Noo*)}x100

Where,

Nij= Number of papers having *j*-authors from country *i*,

Nio= Total output of country *i*,

Noj= Number of papers having *j*-authors from all countries,

Noo= Total output for all countries and all authors

j = 1, 2, 3, …n

Here, 'all' implies all the countries included in the study.

CAI = 100 implies that a country's co-authorship effort for a particular type of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship

effort, and CAI < 100 lower than average co-authorship effort by that country for a given type of authorship pattern. The measure is different than what has been suggested by Bordons. [16]

5.3 Collaborative Index: Domestic (DCI) and International (ICI)

Garg &Padhi proposed indicators to measure the Domestic and International Collaboration. DCI is obtained by calculating the proportional output of domestically co-authored papers. Formula to calculate is

DCI = {(*Di/Dio*)/(*Do/Doo*)}x 100

Where,

Di = Number of domestically co-authored papers for country *i*,

Dio= Total output for country *i*,

Do = Number of domestically co-authored papers from all countries,

Doo = Total output for all countries.

Here, 'all' implies all countries included in the study.

The value of ICI is measured by calculating the proportional output of internationally co-authored papers using the formula

ICI = {(I*i*/I*io*) / (I*o* /I*oo*)} x100

Where,

I*i* = Number of internationally co-authored papers for country *i*,

I*io*= Total output for country *i*,

I*o* = Number of internationally co-authored papers for all countries,

I*oo*= Total output for all countries.

Here, 'all' implies all countries included in the study.

The value of DCI or ICI = 100 implicates any individual Institute's/Country's collaborative effort with respect to the average percentage of the rest. DCI or ICI > 100 reflects collaboration higher than the world average and DCI or ICI < 100 indicates collaboration less than the world average.

5.4 Activity Index

Activity Index [Frame (1977); Schubert and Braun (1986)] is the measure of the relative research effort of a particular country in a given field. It is computed using the following formula;
AI= {(given field's share in the country's publication output) / (given field's proportion in the world's publication output)} x 100

AI = {(Ii / Io) / (Wi / Wo) } x 100 (4.8)
Where,
Ii = Indian output in the year i
Io = Total Indian output
Wi = World output in the year i
Wo = Total output.

6. Results and discussion

6.1 Co-authorship Index and Collaborative Coefficient for Different Institute

Table1 shows the Collaboration pattern along with the Co-Authorship Index of top ten Academic/Research Organizations working in the field of Biotechnology. The single co-authorship pattern computed highest 166 for the Vellore Institute of Technology, whereas All India Institute of Medical Sciences (AIIMS) had the lowest value (41). The Panjab University (159) scored the highest Co-authorship Index in two author papers and the lowest value was recorded again for All India Institute of Medical sciences (41).For three author publications, Banaras Hindu University (117) has the highest value followed by Punjab University (108). The Indian Agriculture Research Institute dominates in the category of four author publication (145). Highest value is recorded for AIIMS (208) in the category of mega-author publications which has been keeping the lowest value in most of the categories under Co-authorship Index.

Table 1: Collaboration pattern and Co-Authorship Index of top Academic/Research Organizations

Institute	Single author papers(CAI)	Two author papers(CAI)	Three author papers(CAI)	Four author papers(CAI)	Mega author papers(CAI)	Total	Collaboration Coefficient
CSIR	75(60.7)	107(74)	118(104)	109(124)	208(137)	617	0.61
AU	156(127)	159(111)	118(105)	70(80)	109(72)	612	0.48
IISc	125(102)	151(106)	103(92)	67(77)	162(108)	608	0.53
BHU	169(146)	174(129)	124(117)	64(77.8)	46(32)	577	0.44
UD	105(91)	123(91)	111(105)	78(95)	159(112)	576	0.55
AIIMS	44(41)	51(41)	63(64)	102(134)	272(208)	532	0.67
PU	107(105)	190(159)	101(108)	51(70)	61(48)	510	0.48
VIT	152(166)	106(95)	81(93)	60(88)	75(64)	474	0.44
IARI	61(64)	89(80)	88(97)	98(145)	138(118)	474	0.60
UM	90(101)	115(111)	83(102)	74(117)	80(73)	443	0.52
Total	1084	1265	990	773	1330	5423	0.64

6.2 Domestic, National and International collaborative Index

Table 2 shows the distribution of papers which are published either by domestic and international collaboration during the study period i.e. 2001-2016. It indicates Panjab University has highest DCI value (116) closely followed by Vellore Institute of Technology (115) and Anna University (114). Indian Institute of Sciences (IISc) has the highest International co-authorship Index (155) profile followed by University of Delhi (135) and CSIR. The result shows that out of 5423 publications, 1106 (20.3%) publications had international collaboration. For CSIR see above comments

No	Institute	Domestic Collaborative Papers	National Collaborative Papers	Total	Domestic Collaborative Index(DCI)	International Collaborative Papers	International Collaborative Index(ICI)	Total Paper
1-	CSIR	337	135	472	(100)	155	(123)	617
2-	AU	415	120	535	(114)	77	(61)	612
3-	IISc	269	146	415	(89)	193	(155)	608
4-	BHU	312	131	443	(100)	134	(113)	577
5-	UD	230	187	417	(95)	159	(135)	576
6-	AIIMc	247	176	423	(104)	109	(100)	532
7-	PU	355	97	452	(116)	58	(55)	510
8-	VIT	358	60	418	(115)	56	(58)	474
9-	IARI	238	167	405	(112)	69	(71)	474
10-	UM	244	103	347	(103)	96	(106)	443
8-	VIT	358	60	418	(115)	56	(58)	474
9-	IARI	238	167	405	(112)	69	(71)	474
10-	UM	244	103	347	(103)	96	(106)	443
				4127		1106		

Table 2: Top 10 Academic/Research Organizations based on DCI and ICI

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6.3 Top contributing authors of Institute

Table 3 shows the top ten contributing authors in the field of Biotechnology from the Indian Academic/Research Organizations. Kumar, A. from Panjab University has contributed the most number of publications (16.86%; 86) as an individual author. Surolia, A. from IISc, Bangalore follows next with 53 (8.71%) publications to his credit. Lal, R. from University of Delhi (8.50%), Arya, D.S. from AIIMS (7.33%), Pandey, A., from CSIR (6.96%), Abraham, J. from Vellore Institute of Technology (6.32%), Prassana, R. from IARI (6.11), and Varalakshmi, P.

from University of Madras (6.00%) are other significant contributors. See above comment for CSIR. The text is silent about the number of total authors and distribution of papers by authors. In first column give name of the author, and in second give the affiliation of the author. Also give citation per paper and relative citation impact.

No.	Institute	Top contributing Author	Number of articles	% of total Publication
1-	CSIR	Pandey, A.	43	6.96
2-	Annamalai University	Balsubrananium, T.	29	4.73
3-	Indian Institute of Sc.	Surolia, A.	53	8.71
4-	Banaras Hindu University	Agrawal, S.	23	3.98
5-	Delhi University	Lal, R.	49	8.50
6-	All India Institute of Medical Sciences	Arya, D.S.	39	7.33
7-	Panjab University	Kumar, A.	86	16.86
8-	Vellore Institute of Technology	Abraham, J.	30	6.32
9-	Indian Ag. Res. Inst.	Prasanna, R.	29	6.11
10-	University of Madras	Varalakshmi, P.	31	6.00

Table 3: Top contributing Authors of Institute in the present form it is a mere tabulation

6.4 Top Institute and Country collaboration

Table 4 shows International collaboration. United States is the most preferred nation for the Academic/Research Organizations in India. According to the Table 4, all except Vellore Institute of Technology has the highest number of publications in collaboration with the

Academic/Research Organizations in United States. South Korea is the most preferred country by VIT for the research in the field of Biotechnology.

No.	Institute	Collaborating Country	Number of Article	% of total article
1-	CSIR	United States	35	5.62
2-	Annamalai University	United States	19	3.10
3-	Indian Institute of Science	United States	61	10.03
4-	Banaras Hindu University	United States	20	3.46
5-	University of Delhi	United States	62	10.76
6-	All India Institute of Medical Sciences	United States	40	7.51
7-	Panjab University	United States	17	3.33
8-	Vellore Institute of Technology	South Korea	11	2.32
9-	Indian Agricultural Research Institute	United States	19	4.00
10-	University of Madras	United States	10	2.25

Table 4: Top ten collaborating Institute and Country

6.5 Citation pattern of Institute

Table 5 shows the top ten Research Organizations according to the number of citations received by their publications on Biotechnology. It also enlists the highest cited authors from the respective Organizations, average citation per paper and ratio of cited vs. uncited articles. The highest average citation per paper is recorded for Punjab University (25.34) followed by Delhi University (23.78) and the IISc, Bangalore (19.43). The highest citation for any paper is received by Beg, Q. K. of Delhi University (763) whereas the second highest citation i.e. 670 is received by the author Sinha V.R., from Panjab University.

The Vellore Institute of Technology has 154 uncited papers which is highest for any institute. Annamalai University with 100 and Indian Agriculture Research Institute with 94 stands second and third, respectively, in terms of most number of uncited papers.

No.	Institute	Highly cited author	Total papers	Total Citation	Average Citation per Paper	% of Cited vs Uncited Paper
1-	CSIR	Binod P.(et.al)315	617	9441	16.50	92.8/7.2
2-	Annamalai University	Kathiresan K.,210	612	8537	16.70	83.6/16.4
3-	Indian Institute of Science	Schommer C., 308	608	10611	19.43	89.9/10.1
4-	Banaras Hindu University	Singh S.K., 187	577	7638	15	88.3/11.7
5-	Delhi University	Beg Q.K.,763	576	12251	23.78	89.5/10.5
6-	All India Institute of Medical Sciences	Misra A. 239	532	8791	18.66	88.7/11.3
7-	Panjab University	Sinha V.R., 670	510	11686	25.34	90.5/9.5
8-	Vellore Institute of Technology	Prathna T.C.,194	474	3671	11.35	67.5/32.5
9-	Indian Agricultural Research Institute	Chinnusamy V., 578	474	7032	18.55	80.1/19.9
10-	University of Madras	Krishnaraj C., 411	443	8456	22.02	86.9/13.1

Table 5: Citation pattern of paper, author and Institute

6.6 Top Publishing Journal for Institute (this this should be for entire output)

Table 6 shows top ten journals preferred by the Academic/Research Organizations and their impact factors. *Molecular and Cellular Biology* has the highest Impact Factor, 5.988,and is the

most preferred journal by University of Madras.The lowest Impact Factor (0.954) is noticed for *Journal of Plant Biochemistry & Biotechnology*; the journal has most number of publications from Indian Agriculture Research Institute producing 10.75% of the total publication. The *European Journal of Pharmacology* stands last among the list contributing 2.28 % of the total publication by Anamalai University. Present data on the distribution of papers by publishing country and impact factor.

No.	Institute	Top publishing Journals	Total publication	Impact factors	% of total publication
1-	CSIR	Bio resource Technology	38	5.651	6.15
2-	AU	European Journal of Pharmacology	14	2.896	2.28
3-	IISC	Journal of Biological Chemistry	43	4.125	7.07
4-	BHU	Bio resource Technology	17	5.651	2.94
5-	DU	PLOS One (Public Library of Science)	24	2.806	4.16
6-	AIMS	PLoS One (Public Library of Science)	17	2.806	3.19
7-	PU	Indian Journal of Experimental Biology	16	1.165	3.13
8-	VIT	IIOAB Journal	39	--	8.22
9-	IARI	Journal of Plant Biochemistry & Biotechnology	51	0.954	10.75
10-	UM	Molecular & Cellular Biology	16	5.988	3.61

Table 6: Highly publishing Journals for Academic/Research Institute

6.7 Activity Index profile of Institute

Table 7 enlists top ten Indian Academic/Research Organizations based on their Activity Index in the field of Biotechnology during the period of study (2001-2016). In the sixteen year time span, highest AI (241) is shown by the University of Madras in the year 2009. From 2013-2016, Vellore Institute of Technology has veryhigh AI, in compare to any other Organization. From

2001 to 2005, publication gap also noticed for the VIT. The generalisation of AI shows the Academic/Research Organizations have higher AI than Academic institutions.

BLOCK wise Growth	Year	CSIR	AU	IISc	BHU	UD	AIIM	PU	VIT	IARI	UM	Total
Block 1	2016	66(90.9)	55(80)	44(65)	62(96.8)	74(115)	55(93)	51(90)	106(201)	56(106)	38(77)	607
	2015	82(122)	41(61)	48(73)	82(131)	64(102)	48(83)	44(79.8)	74(144)	63(123)	42(87.7)	588
	2014	71(102)	58(83.9)	53(77.8)	71(109)	61(94)	52(87)	56(94)	92(173)	49(92)	45(90)	608
	2013	73(111)	63(97)	51(79)	67(109)	57(93)	48(85)	37(68)	81(161)	49(97)	31(66)	577
Block 2	2012	80(146)	66(122)	41(76)	54(106)	34(67)	40(85)	42(93)	43(103)	48(115)	32(82)	480
	2011	75(137.5)	61(113)	37(69)	53(104)	51(100)	50(106)	49(109)	25(60)	47(112)	34(87)	482
	2010	62(136.9)	58(129)	55(123)	46(109)	31(73.7)	42(108)	36(96.6)	18(52)	33(95)	16(49)	397
	2009	36(105.4)	42(124)	41(122)	27(85)	31(97.8)	33(112)	34(121)	13(49)	19(72.8)	23(94)	299
Block 3	2008	29(90)	43((135)	33(104)	23(76)	39(120)	32(115)	31(116)	9(36)	19(77)	26(112)	284
	2007	15(54.5)	35(129)	39(145)	22(86)	23(90)	20(85)	35(155)	8(38)	14(67)	28(112)	239
	2006	10(41)	26(108)	37(156)	10(44)	25(111)	28(134)	23(115)	5(27)	13(70)	38(219)	215
	2005	4(20.6)	22(128)	28(164)	7(43)	18(111)	18(120)	15(105)	-	17(128)	30(241)	159
Block 4	2004	3(13.7)	11(71.8)	22(144)	12(83)	17(118)	26(195)	21(164)	-	13(109)	14(126)	139
	2003	4(20.5)	8(52)	34(223)	11(76)	17(118)	12(90)	16(125)	-	12(101)	24(216)	138
	2002	5(38)	13(101)	26(203)	13(107)	16(132)	11(98)	11(102)	-	12(120)	8(85)	115
	2001	2(14.2)	10(77.8)	19(148)	17(140)	18(148)	17(152)	9(84)	-	10(100)	14(150)	116
Total		617	612	608	577	576	532	510	474	474	443	5423

Table 7: Activity Index profile of Institute

6.8 Open vs. Close access journal profile of Institute (this should go with journals and for entire data)

Table 8 indicates All India Institute of Medical science has published in open access journal more than any other institute/organization which is 26.69% of the total publications. The second highest is Indian Institute of Sciences with 22.53% publications in open access journals. Lowest value isrecorded for Indian Agriculture Research Institute with 11.18% publications in open access journals.

Table 8: Open vs. Close access journal profile of Institute

No.	Organizations	Open access Journal	Closed access Journal	Total Journal	Total Citation
1-	CSIR	108 (17.50)	509 (82.50)	617	9441
2-	Annamalai University	95 (15.52)	517 (84.48)	612	8537
3-	Indian Institute of Science	137 (22.53)	471 (77.47)	608	10611
4-	Banaras Hindu University	82 (14.21)	495 (85.79)	577	7638
5-	University of Delhi	90 (15.62)	486 (84.38)	576	12251
6-	All India Institute of Medical Science	142(26.69)	390 (73.31)	532	8791
7-	Panjab university	93(18.23)	417 (81.77)	510	11686
8-	Vellore Institute of Technology	103(21.72)	371 (78.28)	474	3671
9-	Indian Agricultural Research Institute	53(11.18)	421 (88.82)	474	7032
10-	University of Madras	55(12.41)	388 (87.59)	443	8456

6.9 Collaboration between Private vs. Government Research Organizations

Table 9 presents the collaboration of government and private Institute/organizations in the research activity of the concerned field.It shows that 34 private institutions have collaborated with University of Madras for the research in the field of Biotechnology, which is highest for any research institute or organization. 148 government organizations/ institutes have collaborated with Indian Institute of Science and University of Delhi. In total, AIIMS has the highest number of collaborators (1741) with an average of 3.27 Collaborators per paper, highest for any given institute/university.

Table 9: Collaboration Profile between Private and Government Research Organizations

No.	Research Organizations	Private	Government	Total Collaborators	Average Publications in Collaboration APC=(TC/TP)
1-	CSIR	21	139	1471	2.38
2-	Annamalai University	24	136	1082	1.76
3-	Indian Institute of Science	12	148	1446	2.37
4-	Banaras Hindu University	24	136	1265	2.19
5-	University of Delhi	12	148	1405	2.43
6-	All India Institute of Medical Science	24	136	1741	3.27
7-	Panjab university	17	143	943	1.84
8-	Vellore Institute of Technology	23	137	760	1.60
9-	Indian Agricultural Research Institute	14	146	1211	2.55
10-	University of Madras	34	126	902	2.03

Note- APC (Average Publications in Collaboration**), TC (Total Collaboration), TP (Total Publication)**

7. Findings of Study

- The pattern of second authorship collaboration dominant on other author collaboration pattern in all Academic/Research Organizations.
- The highest collaboration coefficient noticed between 0.67 and 0.44.
- The domestic collaboration pattern is higher than national and international pattern of collaboration.
- The top contributed author (16.86 %) for any institute is Kumar, A. from Punjab University.
- 90% of top ten Academic/Research Organizations has most number of collaborations with the research organizations of United States.
- Punjab University has the highest average citation per paper.
- The journal *Molecular and Cellular Biology* has received highest number of publications from Madras University. The IF of the Journal is 5.988 which is highest for any other journal publishing in the field of Biotechnology.
- The Activity Index analysis shows the inconsistent pattern for every institute.
- The All India Institute of Medical Sciences has published its 26.69% of article in Open Access journal which is highest by any institute whereas Indian Agriculture Research Institute (IARI) has the lowest, 11.18%, number of publications in Open Access Journal.
- All India Institute of Medical Science has the highest (3.27) average number of collaborators.

8. References

1- CHATURVEDI (S) (2002). Status and Development of Biotechnology in India: An Analytical Overview. RIS Discussion Papers. Available at *https://www.ris.org.in/images/RIS_images/pdf/dp28_pap.pdf*

2- PARAMESWARAN (R) (2015). Research output of Anna University: A Scientometric Study. *Knowledge librarian- An International Peer Reviewed Bilingual E-Journal of Library and Information Science,* Vol. 2 (2).

3- BALASUBRAMANI (R) (2014). Mapping the research productivity of Banaras Hindu University: A Scientometric Study. *Journal of Theoretical and Applied Information Technology*. Vol. 59 (2).

4- HASAN (NABI) and SINGH (MUKHTAR) (2015). Research Output of Indian Institutes of Technology (IITs): A Scientometric Study. *Qualitative and Quantitative Methods in Libraries* (QQML) 4: 293—305.

5- MAHBUBA (DILRUBA) and ROUSSEAU (RONALD) (2010). A Scientometric Analysis Of Health And Population Research In South Asia: Focus On Two Research Organisations. Malaysian Journal of Library & Information Science, Vol.15 (3), 135-147.

6- MAHADEVA (S), SHASHIKIRAN (M) and KARIGOWDA (D) (2017). Scientometric Analysis of Research Publications of Indian Institute of Technology Kharagpur: A study based on Indian Citation Index (2004 -2016). *International Journal for Innovative Research in Multidisciplinary Field*. Vol. 3(2) (Available online on – www.ijirmf.com Page 160)

7- SINGH (VIVEK KUMAR) (2015). A Scientometric Study of Research Output of Indian Institute of Technology, Guwahati. Indian J. Sci. Res. 11 (2): 81-84

8- M. (PRAKASH) (2017). Indian Contribution to Biotechnology Research: Scientometric Analysis. *Journal of Advances in Library and Information Science*. Vol. 6 (1), 36-40

9- PATRA (SWAPAN KUMAR) and CHAND (PRAKASH) (2005). Biotechnology Research Profile of India. National Institute of Science Communication and Information Resources. Vol. 63(3), 583-597

10- AJIFERUKE (I), BURREL (Q) and TAGUE (J) (1988). Collaborative Coefficient: A Single Measure of the Degree of Collaboration in Research. *Scientometrics*, Vol. 14(5-6), 421-433.

11- DE SOLLA PRICE (D. J.) & BEAVER (D.B.) (1966). Collaboration in an Invisible College. *American Psychologist*, Vol. 21(11), 1011-18.

12- GARG (K.C.) and PADHI (P) (2001). A study of Collaboration in Laser Science and Technology. *Scientometrics*, 2001, 51(2), 415-27

13- DE SOLLA PRICE (D. J.) (1981). The analysis of Scientometrics for Policy Implications. *Scientometrics*, Vol. 3, 47-54.

14- FRAME (J.D.) (1977). Mainstream Research in Latin America and Caribbean, *Interciencia*, Vol. 2, 143-48.

15- SCHUBERT (A) and BRAUN (T) (1986). Relative Indicators and Relational Charts for Comparative Assessment of Publication Output and Citation Impact. *Scientometrics*, Vol. 9, 281- 291.

16- BORDONS (M) GOMEZ (I) and TERESA FERNANDEZ (M) (1996). Local, Domestic and International Scientific Collaboration in Biomedical Research. *Scientometrics*, Vol. 37(2), 279-95.

17- KARKI (M.M.S) and GARG (K. C) (1997). Bibliometrics of Alkaloid Chemistry Research in India. Journal of Chemical Information and Computer Science, Vol. 37, 157-161.

18- YAO (QIANG) et.al. (2014). Scientometric Trends And Knowledge Maps Of Global Health Systems Research. BioMed Central. (Available at *https://doi.org/10.1186/1478-4505-12-26*.)s

19- SAVANUR (KIRAN) AND SRIKANTH (R). Modified Collaborative Coefficient: A New Measure for Quantifying Degree of Research Collaboration. (Available at *https://pdfs.semanticscholar.org/8816/5604ffbb2403ab1b00a57d5c1f89b3f05f27.pdf*.)