6-2019

Scientometric mapping of research output of NIRF first ranked institute of India: IISc, Bangalore

Satish Kumar
IIT(ISM) Dhanbad, sklisc@gmail.com

Senthilkumar R.
Kongunadu Arts & Science College, Coimbatore, kasclibrary@yahoo.com

Scientometric mapping of research output of NIRF first ranked institute of India: IISc, Bangalore

Satish Kumar
Assistant Librarian, IIT (ISM), Dhanbad
sklisc@gmail.com

R. Senthilkumar
Librarian (SG) & Head (Research), DLIS
Kongunadu Arts & Science College, Coimbatore
kasclibrary@yahoo.com

Abstract

The study is aimed to investigate the scientific research productivity of India's NIRF first ranked higher academic & research institute, Indian Institute of Science (IISc), Bangalore for a period of 05 years during 2014-2018. A total of 12,130 research papers were retrieved as SCIE publication from WoS bibliographical database and analyzed. The study is focused to find out the year wise institutional contribution in research, compound annual growth rate, areas of interest, collaborating institutions and countries, mode of publications, research funding agencies, prolific journals, prolific authors, authorship pattern, degree of collaborations etc. Different scientometric tools and techniques were used to analyze the data and interpretation has been done accordingly to draw out the meaningful result in evaluating the research productivity of the institute.

Key Words: Research Productivity, Scientometrics, Bibliometrics, Citation Analysis, Web of Science.

1. INTRODUCTION

Research productivity of an institution is judged through the different evaluative measures in quantitatively as well as qualitatively. The research output as research paper publication is one of the key and vital source to evaluate the level of a higher academic and research institute. It is very much important for an institute to published high quality research in this cutting age

technological environment to be in the good position at national as well as international level of rankings.

The publication in referred reviewed journals of high class (i.e. high impact journals) has become an important decisive factor for academic ranking in the competition of global or national university ranking. The higher academic ranking is needed to get the funds from government, attract the best mind to work or learn in the institute as well as bring laurel and prestige to the institute at national or international level. Worldwide, Universities are busy in the intellectual race of ranking and research publication play a vital role in obtaining the good rank.

But, in fact, most of the Indian universities are educational institutions and their emphasis is on teaching and learning, completing the syllabus; less focused has been given on improvement of research and publication profile. Very few Indian Universities are focused on high quality research.

Indian Institute of Science, Bangalore is one of the high level academic institute of India which has research focused academic environment that makes it a unique and prestigious research institute of the country. It is National Institutional Ranking Framework (NIRF), MHRD, GOI's ranked number one institute of the Country. It appears with a good rank in world's ranking of different academic ranking agencies.

2. LITERATURE REVIEW

Several studies have been carried out to evaluate the research productivity of an institution, country, continent, specific geographic location, subject, author etc. Vital factors have been identified; complexity of variance explained and remedies have been suggested to overcome. These studies have shown a mirror to the researchers and policymakers in preparing the future road map. Moed[1]et al. (1985) found that bibliometric indicators can operate as a 'monitoring device' for management and policy making in University and research institutions, if used in proper way. Some of the bibliometric research studies are as follows:

Koganuramath[2] et al. (2002) analyzed 663 research papers published by the faculties of Tata Institute of Social Science (TISS) during 1990-2000 and shown the research growth,

collaboration pattern, prolific authors, core journals. The main objective to carry out study was to provide a glimpse of the productivity of TISS faculties and their area of specializations. Mukherjee[3] (2010) carried out a research on the performance of Asian countries in LIS journals during 2001-2007 as indexed by Web of Science bibliographic database and applied various parameters to map the performance such as growth of literature, publication types, authorship patterns, national and international collaboration, citation patterns etc. she shown that China found on top position followed by Taiwan and South Korea. Lariviere[4] et al. (2012) conducted bibliometric study of LIS literature published in the hundred years. It was found that more than 60 % of the authors from LIS field had published in other disciplines in the year 2010. Since 1990, LIS literature has incorporated citations from outside of the LIS field, particularly from management and computer science. Kaur and Mahajan[5] (2012) conducted a comparative assessment of research publications of two leading medical sciences institution –AIIMS, New Delhi and PGIMER, Chandigarh using SCOPUS database and found that AIIMS contributed more publication than PGIMER. Majhi and Maharana[6] (2012) analyzed the growth and development of Physical Science Research in Sambalpur University in research publication as shown in SCOPUS database for the period of 1971-2010 and found that a total of 417 research papers were published by the researchers. Beerkens[7] (2013) reported in her studies on Australian universities. She used a research management index that aggregates a number of management practices at the institutional, school and individual level. She found that universities with rigorous research management systems are related with better research productivity. Zyoud[8] (2014) carried out a bibliometric analysis of research productivity of Malaysian publications in important toxicology journals. 290 papers were retrieved from 55 referred research journals. 42 papers (14.5%) were published in without impact factor journals. Malaysia's most collaborating countries were in the Asia-Pacific regions (18.3%), mainly India and Japan, followed by the Middle East and Africa (10.0%), especially Palestine and Yemen. Jabeen[9] et al. (2015) carried out a research on publication trends of library science scholars and found that a total of 18,371 research articles were published during 2003-2012. A significant growth rate (11.37 %) was observed in the year 2009. Self-citation trend have been escalating with an average rate of 38.56 %. Journal 'articles' were the most popular publication media among LIS researchers. China has contributed remarkably in terms of collaborative publications. Siwach and Kumar[10] (2015) conducted a research to evaluate the the research contributions of MDU, Rohtak in terms of

publication output during the period 2000-2013 as indexed in Scopus database. The study analyzed the year-wise research publications, citations received, most collaborating institutions and countries. Kumar[11] (2018) conducted a study on research productivity of ARIES, Nainital and shown the literature growth, research trend, publication type, preferred journals, citations, prolific author and collaborating institutions as well as countries, project based research, publication pattern and degree of collaboration. It was observed that multi-authorship trend is growing.

It can be concluded from the above literature review that the bibliometric studies have been done in several previous studies to evaluate the quantitative performance of an individual's author, organization, subjects, nation, and continent to get meaningful information to help the management and policy makers.

3. THE INSTITUTE PROFILE

Indian Institute of Science (IISc), Bangalore is a public funded institute for higher education and research in science, engineering, design, and management. It is a premier scientific and research institute in India which has been ranked first in the 'overall' category of ranking for the last three consecutive years (2016-2018) in the NIRF rankings (MHRD, Government of India). It is located in Bangalore- a metro city in Karnataka state of India. IISc was established in 1909 with the active support from Jamsedji Tata (An industrialist & Philanthropist) and Krishna raja Wodeyar IV (Maharaja of Mysore state). It is locally known as "Tata Institute". It was granted the status of Deemed University in 1958. The campus houses more than 40 departments and centers. The institute is developing another campus at Challakere in Chitradurga district, 225 kms from Bangalore campus.

4. OBJECTIVES OF THE STUDY

The objectives of the study are as follows:

1. To study the research growth pattern of IISc publications during 2014-2018.
2. To know the most collaborating institution as well as country in research.

3. To examine the authorship pattern in research.
4. To examine most prolific author of the institute.
5. To map the highly preferred journals for publication.
6. To find out the funding agencies for project based research.
7. To know the degree of collaboration among the authors.
8. To find out the Publication trend, citations received and H-Index of the prolific authors.

5. STATEMENT OF THE PROBLEM

The problems drawn in the present research can be shown through the following questions:

- What is the level of research productivity of faculties of IISc in respect of referred research publications in different areas of their research?
- What is the trend of research in respect of the frequency of publication, source of publications, areas of research, collaborating institutions and countries, authorship pattern, funding agencies, degree of collaborations, citations etc?

6. SCOPE & LIMITATIONS OF THE STUDY

The Scope of the present study is to evaluate the research publication productivity of IISc, Bangalore. The study is limited up to the analysis of the referred research publication of IISc, Bangalore published during 2014-2018 and indexed in SCIE.

7. METHDOLOGY

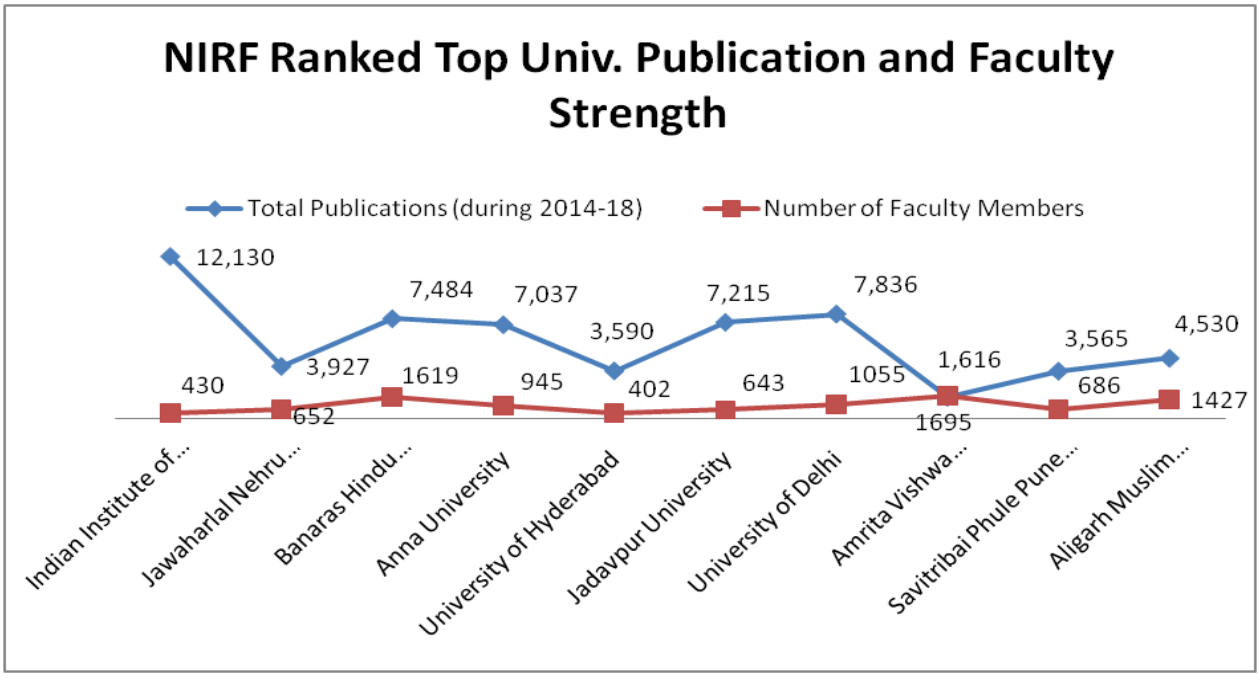
For this study, the data was retrieved from well known bibliographic database, Web of Science[12], Science Citation Index –Expanded (A product of Clarivate Analytics). Data was retrieved with the help of the search term, OG= (Indian Institute of Science IISc Bangalore), using in 'Advance Search'. A total 12,130 research papers bibliographical data was harvested. The data was downloaded and saved in different format for analysis with Scientometric tools. Scientometrics analysis and visualization tools viz. Bibexcel, Pajek, VOSViewer, excel etc. were also used for data analysis, visualization & interpretation.

8. DATA ANALYSIS AND INTERPRETATION

8.1 NIRF 2018 Ranked Top Ten University's Publications

NIRF Rank 2018	University	Publications (2014-18)	Number of Faculty Members	Publication per Faculty	Publication wise ranking
1	Indian Institute of Science (IISc), Bangalore	12,130	430	**28.21**	**1st**
2	Jawaharlal Nehru University (JNU), New Delhi	3,927	652	6.02	7th
3	Banaras Hindu University (BHU), Varanasi	7,484	1619	4.62	3rd
4	Anna University, Chennai	7,037	945	7.45	5th
5	University of Hyderabad (UoH), Hyderabad	3,590	402	8.93	8th
6	Jadavpur University, Kolkata	7,215	643	11.22	4th
7	University of Delhi, Delhi	7,836	1055	7.43	2nd
8	Amrita Vishwa Vidyapeetham, Coimbatore	1,616	1695	0.95	10th
9	Savitribai Phule Pune University(SPPU), Pune	3,565	686	5.2	9th
10	Aligarh Muslim University (AMU), Aligarh	4,530	1427	3.17	6th

Table-01



Graph-01

The above Table-01 shows the publication output of National Institutional Ranking Framework (NIRF) ranked top ten institutions of India. Indian Institute of Science has highest research papers in terms of number (12,130) as well as average publication per faculty (28.21) among the top ten institutions. NIRF's second ranked institute-JNU, New Delhi have more number of faculty than IISc, Bangalore but produced 3,927 research papers during 2014-18 which is 32.37 % of IISc publications. DU, BHU, Jadavpur University, Anna University, AMU, UoH, SPPU and Amrita Vishwa Vidyapeetham holds third to tenth ranked respectively among the top ten NIRF ranked institution of India. Jadavpur University has 2nd highest number of average publication per faculty (11.22) which is 39.77 % of average publication per faculty of IISc, Bangalore. The graph-01 also clarifies the productivity of top ten different NIRF ranked institutions of India.

8.2 Year wise output of IISc publications

Year	Publication (%)	CAGR*	Total citation received	Average citation per paper	Citing Articles	H-Index
2014	2282 (18.81)	-	24763	10.65	21,967	55
2015	2434 (20.07)	6.66 %	21,009	8.63	18,514	48
2016	2400 (19.79)	-1.4 %	16,143	6.73	14,624	38
2017	2486 (20.49)	3.58 %	9,924	3.99	8,643	30
2018	2528 (20.84)	1.69 %	4,010	1.59	3,382	17
Total	**12,130 (100%)**	**2.63 %**	**75,849**	**6.31**	**67,123**	**69**

Table-02 *CAGR= Compound Annual Growth Rate

Graph-02

IISc, Bangalore has increased its publication in comparison to its previous year's publication except 2016. Highest publication was counted in the year 2018 during the five years (2014-18) publications. 2014 publication received highest average citation per paper and it was decreased in succeeding years that shows old publication had more periods of time for visibility than recent publications, and that reflected more number of citations than the recent year's publications which is a common phenomenon. Citing articles are less than the cited articles that shows a positive prospect to the research publication of IISc, Bangalore. The average citation per paper was counted 6.31 and H-Index 69. The Compound annual growth rate (CAGR) was found 2.63 % that shows positive research productivity.

8.2 Document Type

Document Type	Publication	Percentage
Journal Articles	9256	76.31 %
Conference Proceeding papers	2264	18.66 %
Reviews	301	2.48 %
Editorial materials	212	1.75 %
Meeting Abstract	135	1.11 %
Correction	49	0.40 %
Letter	37	0.30 %
Book Chapter	19	0.16 %
Biographic Items	18	0.15 %
Book Review	12	0.10 %
Retraction	03	0.02 %
Reprint	01	0.01 %

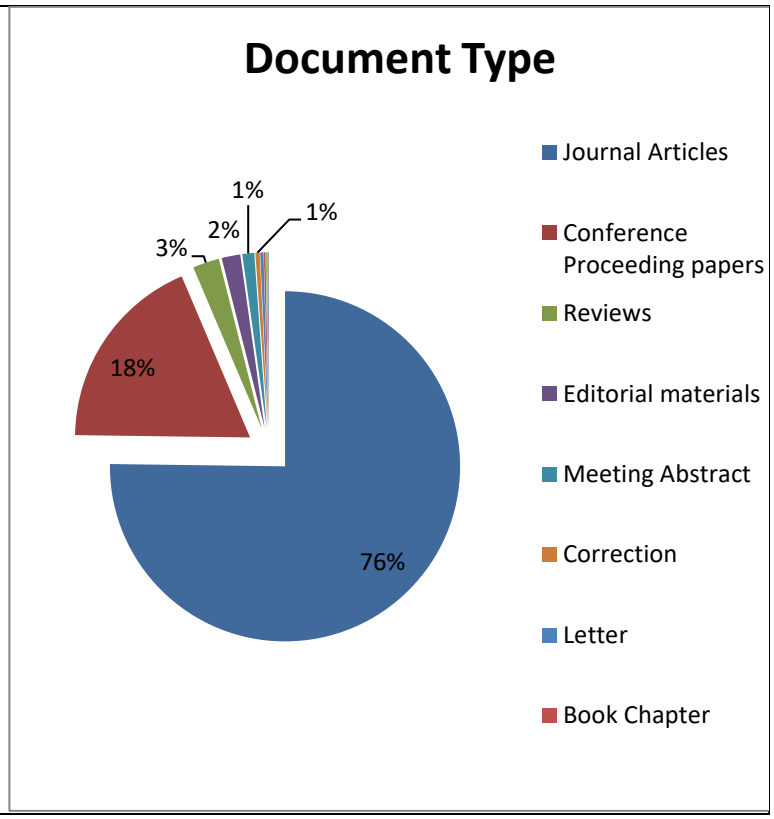


Table-03, Graph-03

IISc, Bangalore has published 9256 (76.31%) research papers as journal articles, 2264 (18.66%) papers in conference proceeding, 301 (2.48%) papers as Reviews, 212 (1.75%) as editorials, 135 (1.11%) as meeting abstract and 49 (0.40%), 37(0.30%), 19(0.16%), 18(0.15%), 12(0.10%), 03(0.02%), 01(0.01%) papers as corrections, letter, book chapter, biographic Items, book review, retraction and reprint respectively. The faculties of IISc, Bangalore are much focused on publishing their research as journals articles followed by conference proceeding papers.

8.3 Open Access

IISc, Bangalore has published 9668 (79.7%) of research papers in subscription based journals/platform and only 2462(20.3%) papers in open access journals/platform which is not much welcoming trend as the subscription based publications are not widely available to the scholar community those have interest in these publication but can't access due to financial constraints.

Accessibility of Publication	Publication (%)	Percentage
Open Access Publication	2,462	20.3 %
Subscription/paid access Publication	9,668	79.7 %

Table-04

8.4 Top 20 Areas of Research

S. No.	Research Area	Publication	Percentage
1.	Engineering	3,054	25.18 %
2.	Physics	2,530	20.86 %
3.	Chemistry	2,236	18.43 %
4.	Materials Science	2,161	17.81 %
5.	Computer Science	1,127	9.29 %
6.	Biochemistry	627	5.17 %
7.	Telecommunications	497	4.18%
8.	Energy Fuels	411	3.39 %
9.	Mathematics	409	3.37 %
10.	Metallurgy	362	2.98 %
11.	Mechanics	349	2.88 %
12.	Optics	323	2.66 %
13.	Astronomy & Astrophysics	281	2.32 %
14.	Environmental Sciences	275	2.27 %
15.	Instrumentation	203	1.67 %
16.	Geology	200	1.65 %
17.	Automation Control Systems	194	1.59 %
18.	Biophysics	187	1.54 %
19.	Crystallography	169	1.39 %
20.	Thermodynamics	165	1.36 %

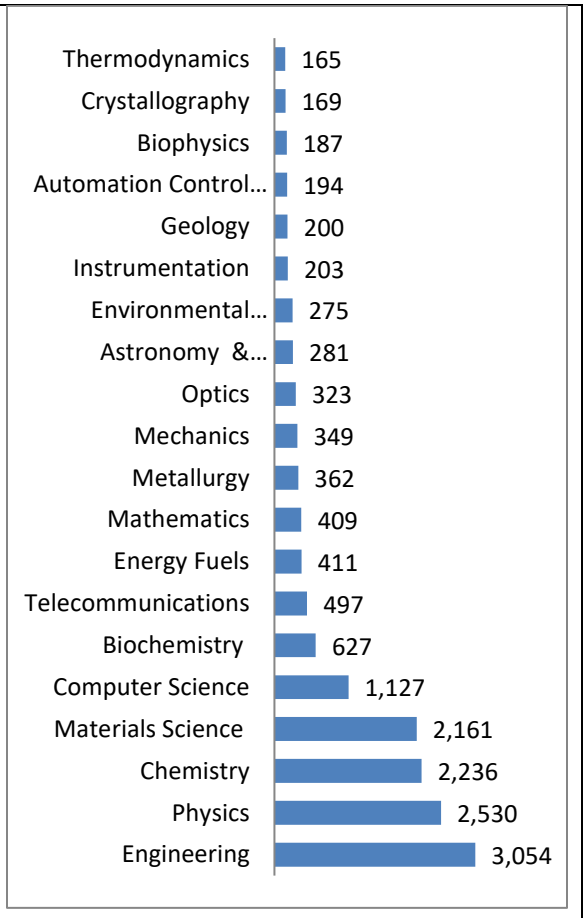
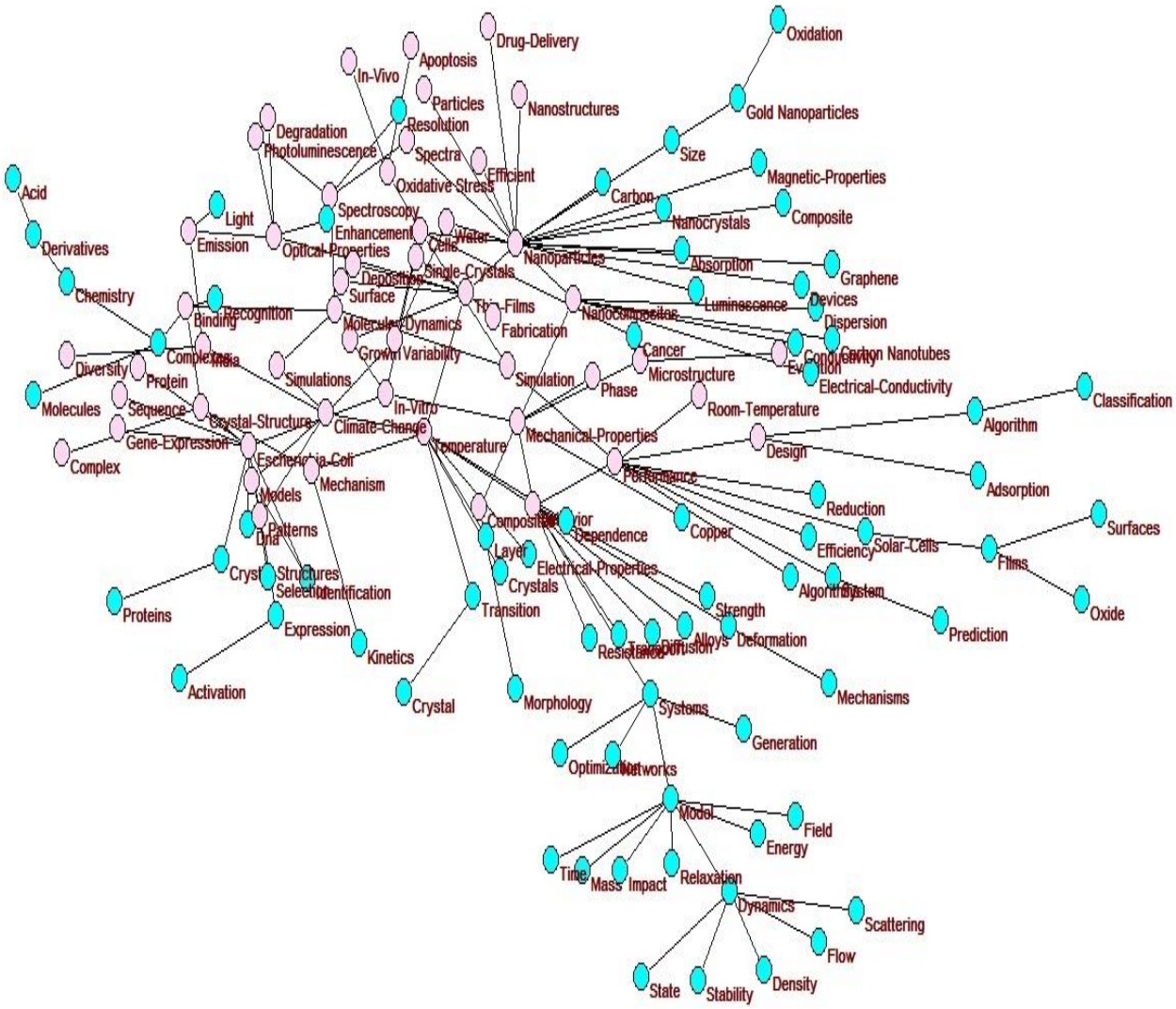


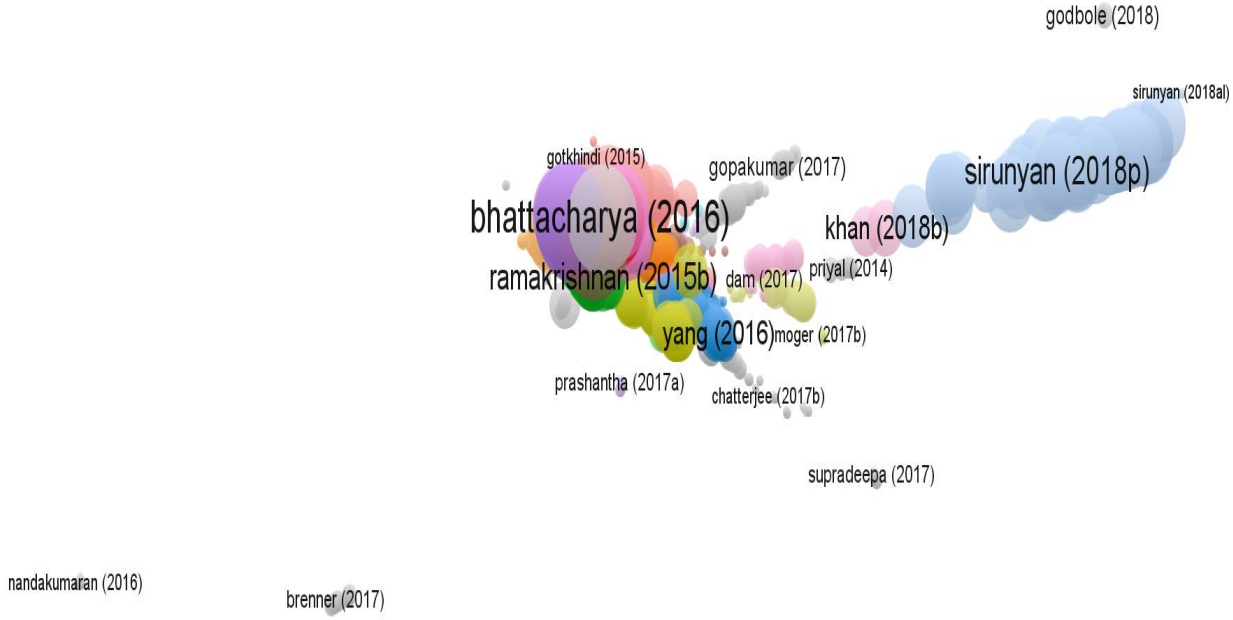
Table-05, Graph-04

IISc, Bangalore has different areas of research in the field of Science & Technology. Engineering (3054), Physics (2530), Chemistry (2236), Material Science (2161) and Computer Science (1127) had major contribution as number of publications during 2014-18 followed by Biochemistry, Telecommunications, Energy Fuels, Mathematics, Metallurgy, Mechanics, Optics, Astronomy & Astrophysics, Environmental Sciences, Instrumentation, Geology, Automation Control Systems, Biophysics, Crystallography and Thermodynamics among the top twenty research areas of publications.



Key Word Clustering Analysis Graph (Graph-05)

Key word clustering graph shows the research trends and interdisciplinary research connectivity. Key word clustering graph shown above (graph-05) is also visualizing the different areas of research and interconnectivity of different field. Different colour of nodes are interconnected are indicating the interdisciplinary research. The key word clustering graph also displays how a research subject is getting connected with others.



Bibliographic Coupling Graph (Graph-06)

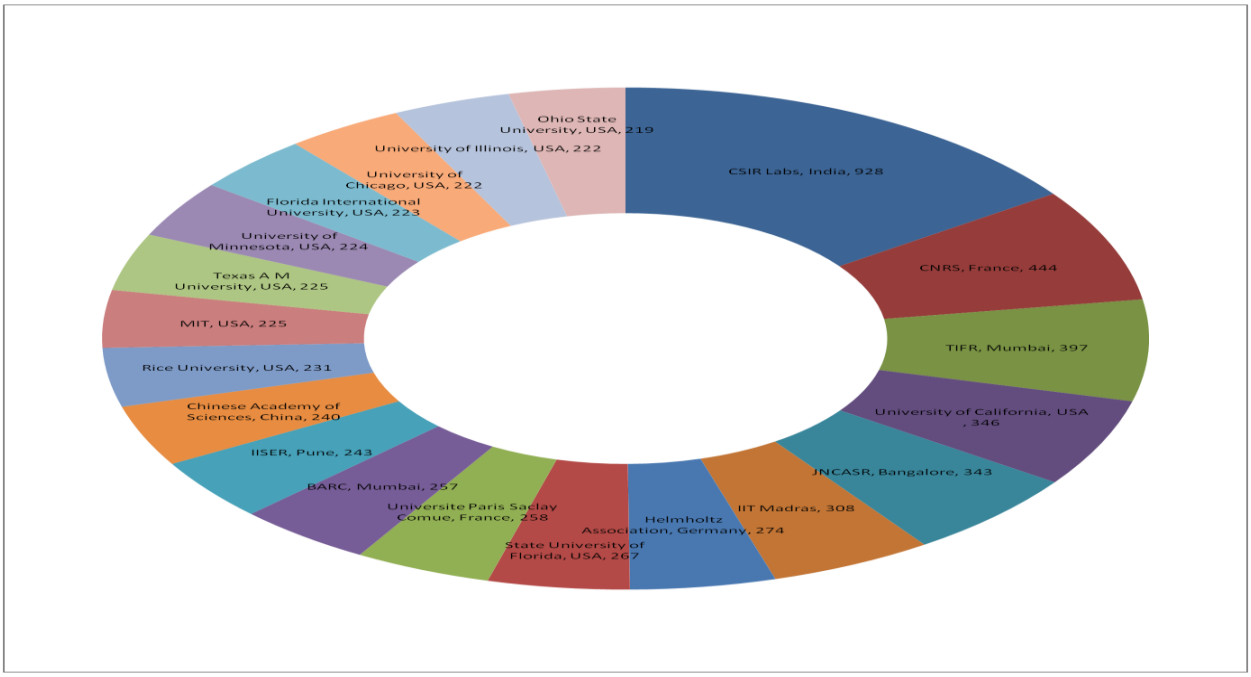
The bibliographic coupling graph shown above as 'graph-06' is visualizing the similarity in the research publications as well as density of the research. The same topic of research has widely investigated and published that shows the dynamics of solving a research problem with different prospects. The size of the different colour of vectors (bubbles) and its overlapping is showing the density of similarity as well as complexity in research publications of IISc, Bangalore.

8.5 Top 20 research collaborating Institutions

S. No.	Collaborating Institution	Publication	Percentage
1.	CSIR Labs, India	928	7.65 %
2.	CNRS, France	444	3.66 %
3.	TIFR, Mumbai	397	3.27 %
4.	University of California, USA	346	2.85 %
5.	JNCASR, Bangalore	343	2.83 %
6.	IIT Madras	308	2.54 %
7.	Helmholtz Association, Germany	274	2.26 %
8.	State University of Florida, USA	267	2.20 %
9.	Universite Paris Saclay Comue, France	258	2.13 %
10.	BARC, Mumbai	257	2.12 %
11.	IISER, Pune	243	2.03 %
12.	Chinese Academy of Sciences, China	240	1.98 %
13.	Rice University, USA	231	1.90 %

14.	MIT, USA	225	1.85 %
15.	Texas A M University, USA	225	1.85 %
16.	University of Minnesota, USA	224	1.84 %
17.	Florida International University, USA	223	1.83 %
18.	University of Chicago, USA	222	1.81 %
19.	University of Illinois, USA	222	1.81 %
20.	Ohio State University, USA	219	1.80 %

Table-06



Graph-07

IISc, Bangalore has research collaboration with different leading research institutions in the world. CSIR Labs are the top research collaborator with IISc, Bangalore followed by CNRS, France; TIFR, Mumbai; University of California, USA; JNCASR, Bangalore and so on. Only six organisations from India are research collaborator among top twenty institutions. Ten research institutions from USA, two from France, one from China and one from Germany are among the top twenty research collaborating institutions with IISc, Bangalore. Collaboration with USA institutions are in dominance.

8.6 Top 20 Collaborating Countries

IISc, Bangalore has maximum research collaboration with USA followed by France, Germany, England, China, South Korea, Italy, Switzerland, Australia, Spain, Taiwan, Austria, Belgium, Brazil, Russia, Finland, Poland, Malaysia, Ireland and Iran respectively among the top twenty countries.

S. No.	Collaborating Countries	Publication	Percentage
1.	USA	1491	12.29 %
2.	France	607	5.00 %
3.	Germany	605	4.99 %
4.	England	525	4.33 %
5.	China	349	2.88 %
6.	South Korea	339	2.79 %
7.	Italy	304	2.51 %
8.	Switzerland	284	2.34 %
9.	Australia	280	2.31 %
10.	Spain	268	2.21 %
11.	Taiwan	258	2.13 %
12.	Austria	249	2.053 %
13.	Belgium	245	2.020 %
14.	Brazil	238	1.96 %
15.	Russia	236	1.94 %
16.	Finland	216	1.781 %
17.	Poland	215	1.772 %
18.	Malaysia	214	1.764 %
19.	Ireland	213	1.756 %
20.	Iran	212	1.75 %

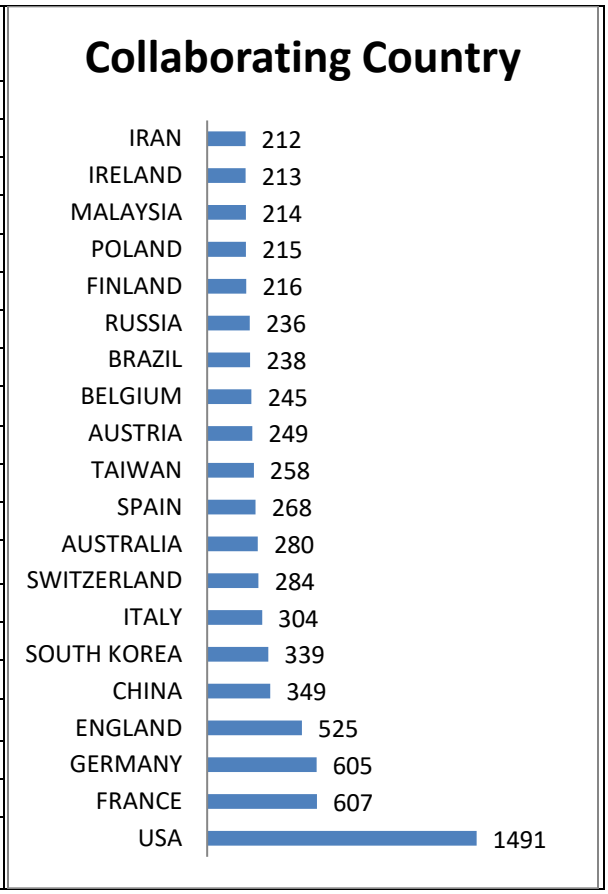


Table-07, Graph-08

Fifteen countries from western world and only five countries from Asian continents are the research collaborating countries among top twenty collaborating countries. IISc, Bangalore has most of the collaboration with developed and leading research countries in the world.

8.7 Top Research Funding Agencies for collaborative research

S. No.	Funding Agency	Country	Publications	Percentage
1.	DST	India	1904	15.69 %
2.	DSIR	India	316	2.60 %
3.	JINR	Russia	186	1.53 %
4.	Alexander Von Humboldt Foundation	Germany	168	1.38 %
5.	CERN	Switzerland	167	1.38 %
6.	CSF	Croatia	158	1.30 %
	FWO	Belgium	158	1.30 %
	INFN	Italy	158	1.30 %
	NRF	Korea	158	1.30 %
	NSFC	China	158	1.30 %
	SFI	Ireland	158	1.30 %
	CNRS IN2P3	France	157	1.29 %

7.	DAE	India	157	1.29 %
	FAPESP	Brazil	157	1.29 %
	FCT	Portugal	157	1.29 %
	GSRT	Greece	157	1.29 %
	HGF	Germany	157	1.29 %
	IPM	Iran	157	1.29 %
	MES	Bulgaria	157	1.29 %
	MESTD	Serbia	157	1.29 %
	UASLPFAI	Maxico	157	1.29 %
	UM	Malaysia	157	1.29 %
8.	BELSPO	Belgium	156	1.28 %
	FWF	Austria	156	1.28 %
	PAEC	Pakistan	156	1.28 %
	RPF	Cyprus	156	1.28 %
	SENES-CYT	Ecuador	156	1.28 %
9.	REDF	Estonia	155	1.27 %
	HIP	Finland	155	1.27 %
	LAS	Lithuania	155	1.27 %
	TAEK	Turkey	155	1.27 %
10.	MBIE	New Zealand	154	1.26 %
	NSC	Poland	154	1.26 %
	NSTDA	Thailand	154	1.26 %

Table-08

DST, India is the top funding agency for project based research among top funding agencies followed DSIR, India; JINR, Russia; Alexander Von Humboldt Foundation, Germany; CERN, Switzerland and so on. Six different funding agencies are on 6th position, eleven on 7th, five on 8th, four on 9th and three funding agencies are on 10th position among the top research funding agencies. Nine Asian countries funding agencies including three Indian funding agencies are among top 34 research funding agencies. Twenty five research funding agencies are from western countries out of 34 top research funding agencies.

8.8 Top 20 Prolific Journals

S. No.	Journal	Publication (%)	Journal Impact Factor#	Total citation received	Average citation per paper	Citing Articles	H-Index
1.	RSC Advances	191(1.57 %)	2.936	2403	12.58	2215	23
2.	Current Sc.	168(1.38 %)	0.883	329	1.96	317	8
3.	Journal of High Energy Physics	162(1.33 %)	5.541	1795	11.08	1290	22
4.	Physical Review B	150(1.23 %)	3.813	1190	7.93	1043	17

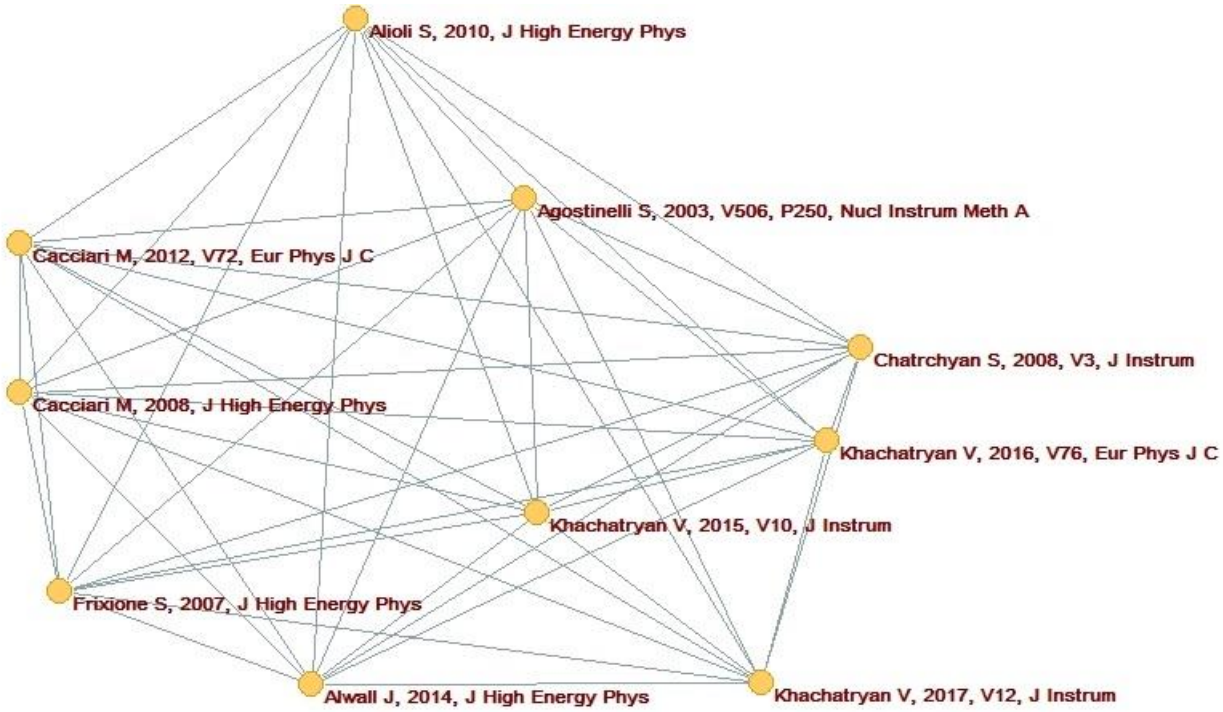
5.	Scientific Reports	148(1.22 %)	4.122	1073	7.25	1054	16
6.	Physical Chemistry Chemical Physics	99(0.81 %)	3.906	1323	13.36	1204	20
7.	Journal of Applied Physics	94(0.77 %)	2.176	593	6.31	572	15
8.	ACS Applied Materials Interfaces	80(0.66 %)	8.097	1643	20.54	1534	23
9.	Journal of Chemical Physics	79(0.65 %)	2.843	433	5.48	391	11
10.	Physical Review D	77(0.63 %)	4.394	741	9.62	667	13
11.	Chemical Communications	76(0.62 %)	6.290	1732	22.79	1608	22
12.	Applied Physics Letters	74(0.60 %)	3.495	523	7.07	487	12
	PLOS One	74(0.60 %)	2.766	618	8.35	597	11
13.	Journal of Alloys and Compounds	71(0.58 %)	3.779	828	11.66	745	17
14.	Resonance Journal of Science Education	66(0.54 %)	0.110*	21	0.32	21	2
15.	Physical Review E	64(0.52 %)	2.284	425	6.64	393	10
16.	Journal of Physical Chemistry C	63(0.51 %)	4.484	575	9.13	571	15
	Journal of the Indian Institute of Science	63(0.51 %)	1.151	44	0.7	44	3
17.	Physical Review Letters	62(0.50 %)	8.839	585	9.44	559	14
18.	Monthly Notices of the Royal Astronomical Society (MNRAS)	58(0.47 %)	5.194	452	7.79	358	12
19.	Materials Science and Engineering: A Structural Materials Properties Microstructure and Processing	52(0.43 %)	3.414	598	5.49	558	13
20.	Crystal Growth Design	50(0.41 %)	3.972	787	15.74	712	17
Total		**2021(16.67%)**	**3.840**	**18711**	**9.26**	**16940**	**47**

#Impact Factor 2018; *Cite Score

Table-09

IISc, Bangalore has published 2021 (16.67%) of research articles in top twenty most prolific journals with average citation 9.26 and H-Index 47. 'RSC Advances' is the most prolific journal

with 191 papers followed by Current Science (168), Journal of High Energy Physics (162), Physical Review B (150), Scientific Reports (148), Physical Chemistry Chemical Physics (99), Journal of Applied Physics (94), ACS Applied Materials Interfaces (80), Journal of Chemical Physics (79), Physical Review D (77) and so on. Physical Review Letter (IF-8.839) is the highest impact factor journal among the top twenty journals followed by ACS Applied Materials Interfaces (IF-8.097), Chemical Communications (IF-6.290), Journal of High Energy Physics (IF-5.541), MNRAS (IF-5.194) and so on. Highest average citation per paper was received by Chemical Communications (22.79) followed by ACS Applied Materials Interfaces (20.54), Crystal Growth Design (15.74), Physical Chemistry Chemical Physics (13.36), RSC Advances (12.58) respectively. ACS Applied Materials Interfaces and RSC Advances publications has highest H-Index (23) among the top twenty most prolific journals followed by Journal of High Energy Physics and Chemical Communication (22) at 2nd position, Physical Chemistry Chemical Physics (20) at 3rd position and so on. IISc, Bangalore has published 08 papers in the highly prestigious journal "Nature" (IF-41.577) during 2014-18 that is a matter of great respect and shows the quality of research at IISc, Bangalore.



Co-Citation Analysis Graph (Graph-09)

The Co-citation analysis graph shown above as graph-09 is showing the gravity in co-citations among the journal's publications. Journal of High Energy Physics, European Physical Journal-C, Journal of Instrumentation and Nuclear Instruments & Methods in Physics Research: Section-A are the top most co-cited publication's journals during 2014-18. Co-citation graph nodes and

connecting threads are showing the bond and density in likeness in the published research with its co-occurrences.

8.9 Top 20 Prolific Authors

S. N.	Author	No. of Publications	Percentage	Total citation received	Average citation per paper	Citing Articles	H-Index
1.	Kumar, A.	372	3.06 %	4538	12.2	3639	24
2.	Kumar, S.	349	2.87 %	4710	13.5	3858	23
3.	Mukherjee, S.	321	2.64 %	3357	10.46	2390	27
4.	Das, S.	301	2.47 %	2159	7.17	1394	20
5.	Bhattacharya, S.	287	2.36 %	3216	11.21	2087	27
6.	Ghosh, S.	283	2.32 %	2292	8.1	1474	21
7.	Kumar, R.	279	2.29 %	3904	13.99	3080	20
8.	Chatterjee, K.	270	2.22 %	2503	9.27	1562	23
9.	Banerjee, S.	259	2.13 %	2284	8.82	1367	23
10.	Sarkar, S.	253	2.08 %	3783	14.95	2297	21
11.	Sharma, V.	237	1.95 %	1663	7.02	939	18
12.	Sharma, A.	231	1.90 %	1856	8.02	1128	18
13.	Kumar, V.	229	1.88 %	1711	7.47	983	18
14.	Roy, A.	223	1.83 %	1777	7.97	1051	18
15.	Sharma, S.	219	1.80 %	3668	16.75	2932	20
16.	Jain, S.	217	1.78 %	1798	8.29	1061	19
	Singh, G.	217	1.78 %	1714	7.9	1002	18
17.	Mitra, S.	214	1.76 %	1758	8.21	991	19
18.	Chatterjee, S.	206	1.69 %	3266	15.85	2703	18
19.	Dutta, S.	204	1.67 %	1574	7.72	854	18
20.	Sarkar, T.	203	1.66 %	1669	8.18	925	18
Total		**5374**	**44.30%**	**55200**	**10.27**	**37717**	**43**

Table-10

Kumar, A. was the most prolific author during 2014-18 with 3.6% contribution in total research and received 12.2 average citation per publications with H-Index 24 followed by Kumar, S.; Mukherjee, S.; Das, S.; Bhattacharya, S. at 2nd , 3rd , 4th and 5th position respectively. Mukherjee, S. and Bhattacharya, S. received highest H-Index (27) among the most prolific authors followed Kumar, A with H-Index 24. Kumar, S.; Chatterjee, K. and Banerjee, S. have H-index 23 followed by Ghosh, S. & Sarkar, A. with H-Index 21. Highest citation per paper was received by Sharma, S. (16.75) followed by Chatterjee, S. (15.85), Sarkar, S. (14.95), Kumar, R. (13.99),

Kumar, S. (13.5) and so on. The top twenty prolific authors have published 5374(44.30%) papers with average citation per paper 10.27 and H-Index 43 that shows the quality as well as quantity in publication by the most productive authors.

8.10 Authorship Pattern and Degree of Collaboration

Year	One Author	Two Author	Three Author	Four Author	Five Author	Six Author	Seven Author	Eight Author	More than eight Author	Total	Degree of Collaboration
2014	91	681	590	362	198	158	81	48	73	**2282**	**0.96**
2015	120	706	580	367	253	140	90	53	125	**2434**	**0.95**
2016	96	680	589	423	232	136	84	54	106	**2400**	**0.96**
2017	93	667	557	388	250	183	97	65	186	**2486**	**0.96**
2018	111	583	540	443	250	147	98	64	292	**2528**	**0.95**
Total (%)	**511 (4.2)**	**3317 (27.3)**	**2856 (23.5)**	**1983 (16.3)**	**1183 (9.7)**	**764 (6.3)**	**450 (3.7)**	**284 (2.4)**	**782 (6.6)**	**12130 (100)**	**0.96**

Table-11

Degree of Collaboration

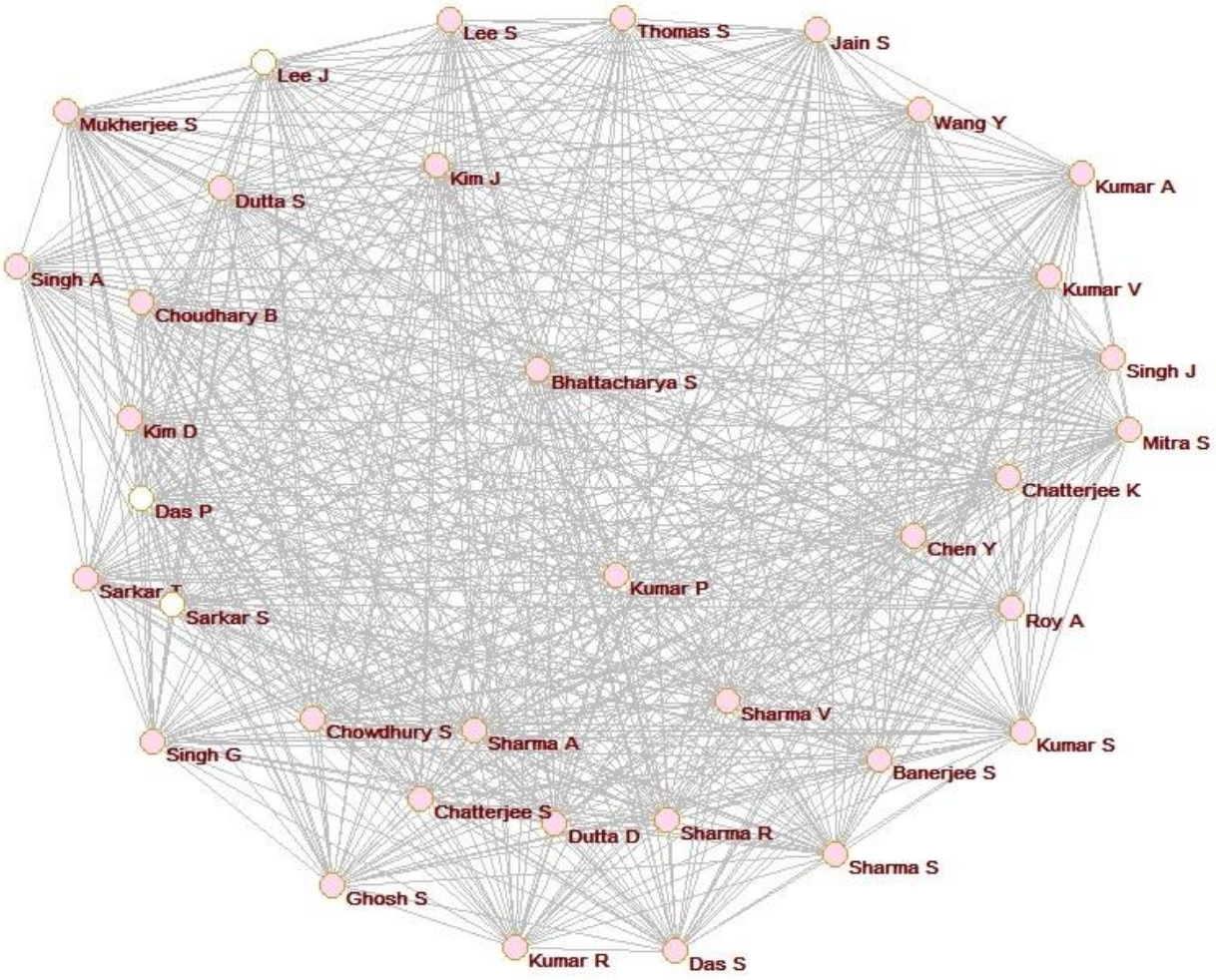
In order to know the collaboration potency i.e. Degree of Collaboration (DC) following formula was given by Subramanyam[13] (1993) has been applied-

$$\mathbf{DC = N_m / N_m + N_s}$$

(Where, DC = Degree of Collaboration, N_m = Number of multiple authored papers and N_s = Number of single authored papers)

So, the Degree of Collaboration (DC) = 11619/11619+511=**0.96**

IISc, Bangalore has published 511(4.2%) papers in single authorship, 3317 papers in two authorship, 2856 papers in three authorship, 1983 papers in four authorship, 1183 papers in five authorship, 764 papers in six authorship, 450 papers in seven authorship, 284 papers in eight authorship and 782 papers in more than eight authorship during the period 2014-18. 511(4.2%) papers are in single authorship and 11619 (95.8%) papers in collaboration. In the year 2014, 2016 and 2017 degree of collaboration was 0.96 and for the year 2015 & 2018, it was 0.95. Over all, the degree of collaboration was calculated as 0.96 that means faculties of IISc, Bangalore are highly interested in collaborative/group research rather than independent research.



Co-Authorship Occurrence Graph (Graph-10)

Co-authorship occurrence graph (graph-10) is visualizing the collaboration network among the highly productive authors of IISc, Bangalore. Most of the prolific authors and their network of research can be seen in the co-authorship occurrence graph.

9. FINDINGS

The following points were observed to summarize the analysis and interpretation of the manipulated bibliographical data related publication of IISc, Bangalore for the year 2014-18:

- Indian Institute of Science, Bangalore has highest research publication (12130) among all NIRF ranked institutions of India. IISc Per faculty publication ratio is 28.21 papers which is also highest among all NIRF ranked institutions. NIRF's second ranked institute-JNU, New Delhi have produced 3,927 research papers during 2014-18 which is 32.37 % of IISc publications which shows there is no institute in India who may show the competitiveness in research publication with IISc, Bangalore and that makes it a highly productive research institute of India.

- IISc average citation per paper was counted 6.31 and H-Index 69 for the period 2014-18. The Compound annual growth rate (CAGR) was found 2.63 % that indicates positive research environment.
- IISc, Bangalore has published 9668 (79.7%) research papers in subscription based journals and 2462(20.3%) papers in open access journals. The publications in open access journals/platform should be encouraged for wider availability of research publication.
- Engineering (3054), Physics (2530), Chemistry (2236), Material Science (2161) and Computer Science (1127) had major contribution as number of publications during 2014-18. Multidisciplinary research has dominance.
- IISc, Bangalore has research collaboration with different leading research institutions in the world. CSIR Labs are the top research collaborator institutes with IISc, Bangalore. Almost fifty percentage most collaborative institutes are from USA.
- IISc, Bangalore has maximum research collaboration with USA and most of the collaboration is with western developed countries.
- DST, India is the top funding agency for project based research among top funding agencies followed DSIR, India.
- IISc, Bangalore has published 2021 (16.67%) of research articles in top twenty most prolific journals which have average citation 9.26 and H-Index 47. 'RSC Advances' is the most prolific journal with 191 publications during 2014-18.
- Kumar, A. was the most prolific author during 2014-18 with 3.6% contribution in total research and received 12.2 average citations per publications with H-Index 24.
- Top twenty prolific authors have published 5374(44.30%) papers with 10.27 average citations per paper whose gross H-Index counted 43 that shows the quality in publication by the most productive authors.
- The degree of collaboration is 0.96 that shows researchers of IISc, Bangalore are focused on collaborative research rather than independent/solo research.

10. CONCLUSION

This work has explored the research publication aspect of IISc, Bangalore from different dimensions to know the research productivity of NIRF's top ranked institute of India. IISc, Bangalore is consistently increasing its research publications and have produced eight research papers during 2014-18 in most prestigious 'Nature' journal that shows the originality as well as quality focused research. There are various factors that contribute in research productivity of an Institution. Research performance must take into account the individual, inspirational as well as structural environmental and the communication among peers. The publication productivity of IISc, Bangalore indicates a healthy research system has developed in the institute that has resulted good number of quality research and makes it India's top ranked institute but it has to move ahead with more sprit to come in the world's best institutions top ranking.

REFERENCES:

1. Moed, H.F.; Burger, W.J.M.; Frankfort, J.G. and Raan, A.F.J. Van (1985). The use of bibliometric data for the measurement of university research performance. *Research Policy*, 14(3), 131-49.
2. Koganuramath, M.M.; Angadi, M. and Kademani, B.S. (2002). Bibliometric dimension of innovation communication productivity of Tata Institute of Social Science. *Malaysian Journal of Library & Information Science*, 7(1), 69-76.
3. Mukherjee, B. (2010). Assessing Asian scholarly research in library and information science: a quantitative view as reflected in web of knowledge. *Journal of Academic Librarianship*, 36(1), 90-101.
4. Larivière, V; Sugimoto, C.R. and Cronin, B. (2012), A bibliometric chronicling of library and information science's first hundred years. *Journal of the American Society for Information Science and Technology*, 63(5), 997-1016.
5. Kaur, H. and Mahajan, P. (2012). Comparative evaluation of research output: AIIMS vs PGIMER. *DESIDOC Journal of Library & Information Technology*, 32(6), 531-36.
6. Majhi, S. and Maharana, B. (2012). Research productivity of physical science disciplines in Sambalpur University (Orissa): a scientometric study. *Researchers World*, 3(4), 108-115.
7. Beerkens, M. (2013). Facts and fads in academic research management: The effect of management practices on research productivity in Australia. *Research Policy*, 42(9), 1679–1693.
8. Zyoud, SH et al. (2014). A bibliometric analysis of research productivity of Malaysian publications in leading toxicology journals during a 10-year period (2003–2012). *Human and Experimental Toxicology*. 33(12), 1284-1293.
9. Jabeen, Munazza.; Yun, Liu and Jabeen, Misbah. (2015). Research productivity of library scholars: Bibliometric analysis of growth and trends of LIS publications. *New Library World*, 116(7/8), 433-454.
10. Siwach, A. K. and Kumar, S. (2015). Bibliometric Analysis of Research Publications of Maharshi Dayanand University, Rohtak during 2000-2013. *DESIDOC Journal of Library & Information Technology*, 35(1), 17-24.

11. Kumar, S. (2018). Scientometric study of Research productivity of ARIES, Nainital. *Library Philosophy and Practice (e-journal).* 1680. https://digitalcommons.unl.edu/libphilprac/1680
12. Web of Science. https://apps.webofknowledge.com/ (accessed on 25.05.2019).
13. Subramanyam, K. (1993). Bibliometric Study of Research Collaboration: A Review. *Journal of Information Science*, 6 (1), 33-38.