RESEARCH OUTPUT OF NATIONAL INSTITUTES OF TECHNOLOGY IN INDIA (2010-2019): A SCIENTOMETRIC ANALYSIS

Iranna M. Shettar
Gururaj S. Hadagali

Mr. Iranna M. Shettar
Dy. Librarian, Central Library,
National Institute of
Technology
Warangal - 506 004,
TELANGANA, INDIA
Email: imshettar@gmail.com
ORCID: 0000-0002-6790-2530
(Corresponding Author)

Dr. Gururaj S. Hadagali
Associate Professor,
Department of Library and
Information Science,
Karnatak University, Dharwad –
580 003, KARNATAKA, INDIA
Email:
gururajhadagali123@gmail.com
ORCID: 0000-0003-1372-4721

The National Institutes of Technology (NITs) are the premier higher educational institutes dedicated to the education and research in the field of Engineering and Technology in India. The present study analyses the research productivity of 31 National Institutes of Technology (NITs) in India. A total of 69,771 records were extracted from the Scopus database for ten years, from 2010 to 2019. The Degree of Collaboration, Collaborative Coefficient, Collaboration Index, authorship pattern, collaborative institutes within India and overseas institutes, collaborative countries, journals preferred etc., were some of the scientometric indicators and parameters used in the study. The study results show that the NIT Rourkela ranked first in publications (8218) and citations (72685); the mean value of Degree of Collaboration for all NITs was 0.9756; Durbadal Mandal from NIT, Durgapur has published the highest number of publications. Indian Institute of Technology, Kharagpur was the most preferred collaborated institute among the authors of NITs; the United States of America has emerged as the most preferred country for collaboration with 1772 publications and D.J. Klionsky, and others received the highest number of citations for their paper (2376).

Keywords: Authorship pattern- Degree of Collaboration, India, Indian Institutes of Technology, National Institutes of Technology, Research Productivity, Scientometric Analysis

INTRODUCTION

Technical education and research have brought rapid changes in the socio-economic development and skills & competencies of individuals and society. Technical education and research have shifted society's focus from agriculture to industrialization to an information-based society (Crawley et al., 2014). National Institutes of Technology (NITs) in India are the premier technical institutes imparting engineering science and technology education and conducting extensive research. These NITs are autonomous, Centrally Funded Technical Institutes governed by the Department of Higher Education, Ministry of Education, GoI as 'Institutes of National Importance' under the National Institutes of Technology Act 2007.

The Ministry of education has established 31 NITs across India with the idea of "One NIT in each State". Hence 31 NITs are located in all 28 states, and the remaining 3 NITs are located in union territories, Delhi, Jammu and Kashmir and Pondicherry. Out of these thirty-one NITs, seventeen were initially established as "Regional Engineering Colleges" (RECs) between 1960 and 1986 as a collaborative joint venture by the State governments of the concerned State and the Central Government of India. RECs were initially affiliated with the universities of the concerned region to promote undergraduate and postgraduate education in Engineering Science and Technology. In 2002, the Central Government upgraded these RECs to National Institutes of Technology (NITs) as deemed to be universities. In 2006, three more state engineering colleges in Patna, Raipur and Agartala were upgraded as NITs. In 2007, all the 20 NITs were declared Institutes of National Importance through NIT Act 2007. Subsequently, ten more NITs were established in 2010 and one in Andhra Pradesh in 2015. Currently, 31 NITs are imparting technical education and promoting research in India. With the Institutes of National Importance status in 2007, NITs were promoted to conduct research activities with higher research funding and develop research infrastructure. This resulted in many NITs being listed in national and international rankings based on their research output and academic frameworks. Though some of the NITs were recently established, and some are upgraded from RECs to NITs, the research programmes are relatively new in NITs. In this context, the present study analyses the research performance of all the 31 NITs for a period from 2010 to 2019 using various scientometric indicators and parameters

REVIEW OF LITERATURE

Technical Institutions in India contribute their significant share to global science and technology research. National Institutes of Technologies were established parallel to the Indian Institutes of Technologies. The present study analyses the publications productivity of the National Institutes of Technology in India for ten years from 2010-2019. The published literature reveals a shortage of studies on the research productivity of NITs; hence the productivity of Indian Institutes of Technology is also considered and reviewed in the following paragraphs.

Bala and Kumari (2013) conducted a bibliometric analysis of the National Institutes of Technology (NITs) in India for ten years, from 2001 to 2010, indexed in the Scopus database. The analysis of 8841 publications by twenty NITs showed a linear growth. Among the twenty NITs, the NIT Rourkela has registered the highest number of publications (1134), followed by NIT Tiruchirappalli (1108). R. Narayana Swamy of NIT Tiruchirappalli was the most productive author with the highest number of publications. The *International Journal of Advanced Manufacturing Technology* was the most preferred overseas Journal, and *Communications in Computer and Information Science* was the most preferred Indian Journal. Arif (2015) examined the top four Indian Institutes of Technology in Computer Science and Engineering. The data was extracted from the

Institute's websites and DBLP database for five years, from 2011 to 2015. A total of 111 faculty members contributed a total of 1082 publications. The authors of Indian Institute of Technology Madras, Chennai have published the highest publications (491) by 27 faculty members, followed by IIT Delhi (288 publications, 27 faculty members), IIT Kharagpur (200 publications, 32 faculty members) and IIT Kanpur (103 publications, 25 faculty members). Multi-authored papers dominate (98.06%) over single-authored papers (1.94%). 9.81 is the average per capita productivity for all the institutes together. A similar study was conducted by Hasan and Singh (2015) on the top five IITs (IIT Mumbai, Delhi, Kanpur, Kharagpur and Chennai) based on the number of publications using the Web of Science database. The top five IITs together published 20,046 publications covering 9.32% of Indian publications during the study period. The IIT Kharagpur published the highest number of publications, followed by IITM, Chennai. The IIT Kharagpur has received the highest number of citations. However, IITB Mumbai has to lead the table with the highest average citations per article. IBM was the most favoured collaborative institute.

Siddaiah et al. (2016) investigated the research performance of eight newly established Indian Institutes of Technologies (established after 2008). A total of 3656 publications were retrieved from the Scopus database between 2010 and 2014. IIT Hyderabad has the maximum number of publications, IIT Indore has received the highest number of citations, and IIT Ropar leads the table in average citations per paper. N. Singh from IIT Ropar has emerged as the most productive author with the maximum number of contributions (82). *RSC Advances* was the most preferred Journal. Banshal et al. (2017) analyze the research performance of IITs established before 2012 and indexed in the WoS database (extracted 79,643 publications) for fifteen years, i.e. from 1990 to 2014. The IITs found after 2008 were also considered for the analysis. For such IITs, the data were collected (32,308) using various indicators for five years, from 2010-2014. IIT Kharagpur has the highest number of publications among the sixteen IITs in the tables of twenty-five years and five years' data.

Vijayakumar (2017) found in his study the research trends among the faculty members and research of IITs. A total of 14,879 records were extracted from the Web of Science published between 1994 and 2004. Two authored papers contributed 37.40% of the total publications, followed by three authored papers with 28.09%. The Degree of Collaboration during the period recorded was 0.93. Solo authors contributed 8.28 % of publications, and two or more authors contributed 91.72%. The study did not validate Lotka's law. Pradhan and Sahu (2018) conducted a bibliometric study to analyze the publication performance of five IITs: IIT Bombay, Kharagpur, Delhi, Kanpur and Madras. A total of 10,583 publications were retrieved from the Scopus database published between 2007 and 2016. The study found that IIT Bombay has published the highest number of publications (2709), followed by IIT Kharagpur (2462), IIT Madras (2303), IIT Delhi (2030) and IIT Kanpur (1079). Australia and USA were the most preferred collaborative countries with IITs.

The study recorded a 0.96 Degree of Collaboration, revealing that multi-authored publications dominate solo author publications.

Pradhan and Ramesh (2018) conducted a Scientometric analysis of 72,940 publications productivity of six IITs from 2006 to 2015 using the Scopus database. The data reveal that IIT Kharagpur has published the highest number of publications (15,173) and citations (11,267), followed by IIT Delhi (14,104 publications). Among the form-wise distribution, 71 % are journal articles. The *Journal of Applied Polymer Science* was the most preferred Journal amongst the researchers of six IITs. 40% of the total publications are cited in international publications, which shows the researchers in these six IITs are publishing quality work.

Banshal, Solanki and Singh (2018) conducted a bibliometric analysis of publications effort by the National Institutes of Technology between 2005 and 2016 using the Web of Science database. A total of 20,307 publications were extracted for these 31 NITs. The publication productivity of these 31 NITs increased 3.5 times during 2011-2016 compared to 2005-2010. The NIT Tiruchirapalli (2,749) and NIT Rourkela (2,621) were the most productive institutions. The NIT Tiruchirapalli ranked first regarding citations received, international collaboration and h-index. The USA and South Korea were the most preferred international collaborative country. Singh and Singh (2019) investigated the research performance of IITs (established before 2015 and other institutions on par with IITs) in Computer Sciences. A total of 1,06,047 publications were retrieved from the Scopus database until November 2018. The IIT Kharagpur led the table with the maximum number of publications (7166), and the Indian Institute of Science (IISc), Bengaluru, ranked first in terms of the highest number of citations. IIT Kanpur ranked first in terms of ACPP, h-index and s-index. None of the IIT and other institutions has more than 100 h-index in Computer Science.

OBJECTIVES OF THE STUDY

The primary objective of this study is to analyze the publication productivity of all the 31 National Institutes of Technology (NITs) in India from 2010 to 2019. The specific objectives of the study are to:

1. examine the publications and citations pattern in NITs in India;

2. study the collaborative measures like Degree of Collaboration (DC), Collaborative Coefficient (CC) and Collaboration Index (CI);

3. analyze the collaboration within India and with overseas authors;

4. know the authorship pattern and identify the most prolific authors in NITs;

5. determine the most preferred journals by authors of NITs; and

6. identify the top five highly cited papers published by authors of NITs.

METHODOLOGY

The present study deals with the Scientometric analysis of National Institutes of Technology publications in India. The data was collected using the Scopus database from 2010

to 2019. Out of 31 NITs, NIT Andhra Pradesh was established in 2015. Hence the publication data for NIT Andhra Pradesh have only five years of data. Individual Scopus affiliation ID of each NIT was identified, and the following search strategy was adopted in the advanced search module:

(AF-ID (60104582) OR AF-ID (…. AND (LIMIT-TO (PUBYEAR,2019) OR …,2010))

A total of 69,771 bibliographic records indexed in the Scopus database were retrieved in the CSV (comma-separated values) file format. Further analysis was carried out using MS-Excel and online tools. Various scientometric indicators and mathematical formulae were used in the study to analyze the publications productivity of NITs.

ANALYSIS AND INTERPRETATION OF DATA

Ranking of NITs based on TP, TC, ACPPs and h-index

Table 1 provides the ranking list of NITs in terms of total publications (TP), total citations (TC) received, average citations per paper (ACPP) and h-index for the period from 2010 to 2019. The study reveals that NIT Rourkela ranked first in terms of total publications (8,218) and total citations (72,685), ranked second in terms of h-index (76) and third in terms of ACPP (8.84). The NIT Tiruchichirapalli ranked second in terms of total publications (6,495) and citations (59480) and first in terms of ACPP (9.16) and h-index (81). NITK Surathkal ranked third in terms of total publications (5,767). NIT Hamirpur ranked second in ACPP (9.01), and NIT Rourkela ranked

third (8.84). The SVNIT Surat ranked third in terms of h-index (65). NIT Rourkela and NIT Tiruchirappalli appeared in the top two positions in all parameters used.

Degree of Collaboration in NITs

The Degree of Collaboration (DC) for the different NITs was calculated using the mathematical formula proposed by Subramanyam (1983) based on two parameters in publications, i.e., Single authored papers and multi-authored papers by individual institutes.

$$\text{Degree of collaboration} = \frac{Nm}{Nm+Ns}$$

Table 2 presents the Degree of Collaboration (DC). The NIT Rourkela has the highest number of publications, both in single-authored papers with 194 publications and multi-authored publications, i.e. 8024. There are 1744 single-authored papers and 69,819 multi-authored papers published by all the NITs. The Degree of Collaboration of the individual institutes over the years from 2010-19 was calculated, ranging from 0.9463 to 0.9891 among institutions. The mean value of the Degree of Collaboration for all NITs is 0.9756. All the NITs recorded an excellent Degree of Collaboration, i.e. more than 0.94. However, the performance of 15 NITs was higher than the mean of the Degree of Collaboration. NIT Goa has recorded the highest Degree of Collaboration (0.9891), and NIT Patna recorded the lowest Degree of Collaboration (0.9463) among the different NITs.

Table 1: Ranking of NITs based on TP, TC, ACPPs and h-index

Name of NIT	Abbreviation	TP	Rank based on TP	TC	Rank based on TC	ACPP	Rank based on ACPP	h-index	Rank based on h-index
NIT Rourkela	NITRKL	8218	1	72685	1	8.84	3	76	2
NIT Tiruchirapalli	NITT	6495	2	59480	2	9.16	1	81	1
NITK Surathkal	NITK	5767	3	30922	5	5.36	16	55	8
NIT Durgapur	NITD	4709	4	34406	3	7.31	7	65	4
NIT Kurukshetra	NITKKR	4104	5	23094	8	5.63	15	54	9
NIT Warangal	NITW	3947	6	22564	9	5.72	13	51	12
MNNIT Allahabad	MNNIT	3785	7	28148	6	7.44	6	59	7
SVNIT Surat	SVNIT	3766	8	33077	4	8.78	4	65	3
MNIT Jaipur	MNIT	3712	9	23155	7	6.24	11	52	10
NIT Calicut	NITC	3339	10	19885	12	5.96	12	51	11
VNIT Nagpur	VNIT	3201	11	20695	11	6.47	10	50	13
NIT Silchar	NITS	2703	12	18068	14	6.68	9	47	14
MANIT Bhopal	MANIT	2564	13	20969	10	8.18	5	63	5
NIT Jalandhar	NITJ	2426	14	16669	15	6.87	8	46	15
NIT Hamirpur	NITH	2203	15	19848	13	9.01	2	59	6
NIT Raipur	NITRR	2070	16	10593	16	5.12	17	36	16
NIT Agartala	NITA	1897	17	9094	17	4.79	18	35	17
NIT Patna	NITP	1191	18	4172	19	3.50	24	22	19
NIT Jamshedpur	NITJSR	971	19	5507	18	5.67	14	33	18
NIT Srinagar	NITSRI	918	20	3223	20	3.51	23	21	21
NIT Meghalaya	NITM	728	21	3153	21	4.33	19	21	20
NIT Goa	NITG	458	22	1513	24	3.30	26	17	25
NIT Durgapur	NITD	417	23	1650	22	3.96	21	18	22
NIT Manipur	NITMN	395	24	1562	23	3.95	22	17	24
NIT Arunachal	NITAP	350	25	885	27	2.53	31	12	29
NIT Uttarakhand	NITUK	293	26	886	26	3.02	29	14	26
NIT Puducherry	NITPY	246	27	1041	25	4.23	20	17	23
NIT Nagaland	NITN	221	28	761	28	3.44	25	13	27
NIT Sikkim	NITSKM	202	29	557	30	2.76	30	10	30
NIT Mizoram	NITMZ	194	30	592	29	3.05	28	13	28
NIT Andhra	NITANP	73	31	241	31	3.30	27	9	31
	Total	71563		489095					

TP= Total Publications; TC= Total Citations, ACPP= Average Citation Per Paper

Table 2: Degree of Collaboration in NITs

Institution	Single authored (Ns)	Percentage	Multi authored (Nm)	Percentage	Total (Ns + Nm)	Degree of Collaboration
NITG	5	1.09	453	98.91	458	0.9891
SVNIT	57	1.51	3709	98.49	3766	0.9849
MNIT	57	1.54	3655	98.46	3712	0.9846
NITMZ	3	1.55	191	98.45	194	0.9845
NITK	90	1.56	5677	98.44	5767	0.9844
NITC	56	1.68	3283	98.32	3339	0.9832
NITM	13	1.79	715	98.21	728	0.9821
NITT	119	1.83	6376	98.17	6495	0.9817
NITW	78	1.98	3869	98.02	3947	0.9802
NITUK	6	2.05	287	97.95	293	0.9795
NITD	101	2.14	4608	97.86	4709	0.9786
NITMN	9	2.28	386	97.72	395	0.9772
NITKKR	95	2.31	4009	97.69	4104	0.9769
NITRKL	194	2.36	8024	97.64	8218	0.9764
VNIT	76	2.37	3125	97.63	3201	0.9763
NITD	11	2.64	406	97.36	417	0.9736
NITS	73	2.70	2630	97.30	2703	0.9730
NITN	6	2.71	215	97.29	221	0.9729
NITH	62	2.81	2141	97.19	2203	0.9719
MNNIT	109	2.88	3676	97.12	3785	0.9712
NITJ	74	3.05	2352	96.95	2426	0.9695
MANIT	84	3.28	2480	96.72	2564	0.9672
NITA	68	3.58	1829	96.42	1897	0.9642
NITAP	13	3.71	337	96.29	350	0.9629
NITSKM	8	3.96	194	96.04	202	0.9604
NITANP	3	4.11	70	95.89	73	0.9589
NITJSR	46	4.74	925	95.26	971	0.9526
NITRR	104	5.02	1966	94.98	2070	0.9498
NITSRI	47	5.12	871	94.88	918	0.9488
NITPY	13	5.28	233	94.72	246	0.9472
NITP	64	5.37	1127	94.63	1191	0.9463
Total	1744	2.44	69,819	97.56	71,563	0.9756

Collaborative Coefficient (CC)

The Collaborative Coefficient (CC) enables the researchers to test the collaboration level among the authors. The calculated value of the Collaborative Coefficient is always between 0 and 1 as defined by Ajiferuke et al. (1988).

$$CC = 1 - \frac{\sum_{j=1}^{A}(1/j)f_j}{N}$$

If the CC value is between 0.5 and 1, it denotes better collaboration between the authors; the collaboration is weak if the value is less than 0.5; the CC value of 1 denotes the perfect collaboration between the authors and 0 denotes no collaboration. Table 3 provides the Collaborative Coefficient (CC) and Collaboration Index (CI) of all NITs. However, considering the overall publications by NITs, two-authored papers dominated with 24,187 (33.8 %) publications, followed by three authored with 22,762 papers (31.81%), and four authored, i.e. 12,362 (17.27%) papers. Table 3 delineated that all the NITs accomplished a higher CC than 0.5. The Collaborative Coefficient of all the publications of NITs was 0.63, which was found to be better collaboration across the NITs.

Collaboration Index (CI)

The Collaboration Index (CI) gives the mean number of authors per paper for the study period. It is merely a formula proposed by Lawani (1980) to find the average number of authors per paper for a particular year.

$$CI = \frac{\sum_{j=1}^{A} jf_j}{N}$$

It considers the total number of authors, including the single author and the total number of papers. The average number of authors per paper across the NITs was 3.40. Only nine NITs achieved higher than the overall Collaboration Index. The remaining 22 NITs reached a lower CI value. The MNIT Jaipur has recorded the highest Collaboration Index, i.e. 4.87, and NIT Kurukshetra has the lowest Collaborative Index (2.72).

Authorship Pattern in NITs

Table 4 presents the authorship pattern in NITs. The data shows that two-authored publications dominate with the highest 23,974 (34.36 %) publications, followed by three-authored with 22,055 (31.61%) publications. The data also shows that 1743 (2.5%) publications are single-authored papers and the remaining 68028 (97.5%) are multi-authored. The solo research is very minimal. The total numbers of authors involved in three-authored publications are highest among the overall authorship patterns with 66,165 (27.99%) authors, followed by two-authored publications with 47,946 (20.28%) authors and four-authored publications with 47,636 (20.15%) authors. Single authored publications represented the lowest number of authors, with only 1743 (0.74 %) authors. Overall, 69,771 research publications were contributed by 2,36,400 authors, with an average of 3.39 authors per paper. The analysis reveals that collaborative research dominates in NITs, a common engineering science and technology phenomenon.

Table 3: Collaborative Coefficient (CC) and Collaboration Index (CI)

Institution	Single Author	Two Authors	Three Authors	Four Authors	Five & Above	Total	Total Authors of Multi-Authored Papers	No. of Total Authors	CC	CI
NITRKL	194	2901	2383	1384	1356	8218	31930	32124	0.63	3.91
NITT	119	1969	1995	1287	1125	6495	21757	21876	0.64	3.37
NITK	90	2080	1811	854	932	5767	18460	18550	0.63	3.22
NITD	101	963	1543	1212	890	4709	16647	16748	0.66	3.56
NITKKR	95	2157	1207	350	295	4104	11076	11171	0.58	2.72
NITW	78	1387	1197	591	694	3947	12870	12948	0.63	3.28
MNNIT	109	1330	1166	649	531	3785	12036	12145	0.62	3.21
SVNIT	57	1540	1198	565	406	3766	13937	13994	0.62	3.72
MNIT	57	762	1226	861	806	3712	18021	18078	0.67	4.87
NITC	56	1275	1081	520	407	3339	10323	10379	0.62	3.11
VNIT	76	1054	1001	568	502	3201	10442	10518	0.63	3.29
NITS	73	962	919	454	295	2703	8154	8227	0.62	3.04
MANIT	84	1031	847	388	214	2564	7458	7542	0.60	2.94
NITJ	74	781	893	404	274	2426	7515	7589	0.62	3.13
NITH	62	760	759	353	269	2203	6881	6943	0.62	3.15
NITRR	104	647	709	351	259	2070	6461	6565	0.61	3.17
NITA	68	527	613	342	347	1897	6430	6498	0.64	3.43
NITP	64	385	391	202	149	1191	3676	3740	0.61	3.14
NITJSR	46	358	328	150	89	971	2805	2851	0.60	2.94
NITSRI	47	338	267	118	148	918	2840	2887	0.60	3.14
NITM	13	172	272	161	110	728	2435	2448	0.65	3.36
NITG	5	116	152	117	68	458	1573	1578	0.66	3.45
NITD	11	124	154	83	45	417	1297	1308	0.63	3.14
NITMN	9	154	106	59	67	395	1290	1299	0.62	3.29
NITAP	13	95	121	75	46	350	1115	1128	0.63	3.22
NITUK	6	69	120	59	39	293	979	985	0.65	3.36
NITPY	13	82	76	49	26	246	751	764	0.61	3.11
NITN	6	73	76	48	18	221	679	685	0.62	3.10
NITSKM	8	46	62	45	41	202	725	733	0.65	3.63
NITMZ	3	44	73	39	35	194	661	664	0.66	3.42
NITANP	3	5	16	24	25	73	310	313	0.70	4.29
Total	1744	24187	22762	12362	10508	71563	241534	243278	0.63	3.40

(CC= Collaborative Coefficient; CI=Collaboration Index)

Table 4: Authorship Pattern in NITs

Authorship Type	No. of Articles	Total No. of Authors	% of Articles	% of Authors
Single Author	1743	1743	2.50	0.74
Two Authors	23973	47946	34.36	20.28
Three Authors	22055	66165	31.61	27.99
Four Authors	11909	47636	17.07	20.15
Five Authors	5362	26810	7.69	11.34
Six Authors	2340	14040	3.35	5.94
Seven Authors	1093	7651	1.57	3.24
Eight Authors	582	4656	0.83	1.97
Nine Authors	284	2556	0.41	1.08
Ten+ Authors	430	17197	0.62	7.27
Total	69771	236400	100.00	100.00

Most prolific authors of NITs

Table 5 shows the top ten authors (based on the number of publications) among the National Institutes of Technology in India. Durbadal Mandal from NIT, Durgapur leads the table with the highest number of publications, i.e. 316 to his credit, followed by Rajib Kar of NIT, Durgapur (295 Publications) and Saktiprasad Ghoshal of NIT, Durgapur (264 Publications). All the top three authors belong to the National Institute of Technology, Durgapur and published 194 research papers together as co-authors.

Among the top ten authors Sambandam Anandan of NIT, Tiruchirappalli received the highest number of citations, i.e. 3684 (197 publications), followed by Saktiprasad Ghoshal of NIT, Durgapur with 3502 citations (264 Publications) and SibaSankar Mahapatra of NIT, Rourkela with 3499 citations (260 Publications) ranked first to third respectively. According to the

Table 5: Most prolific authors of NITs

Name of Author	Institute	TP	TC	ACCP	h-index
Durbadal Mandal	NITD	316	1726	5.46	20
Rajib Kar	NITD	295	1437	4.87	18
Saktiprasad Ghoshal	NITD	264	3502	13.27	31
Siba Sankar Mahapatra	NITRKL	260	3499	13.46	28
Arun Mohan Isloor	NITK	209	3308	15.83	33
Singaravelu V. Raghavan	NITT	200	842	4.21	13
Sambandam Anandan	NITT	197	3684	18.70	33
Rajesh Vijay Kumar	MNIT	183	774	4.23	16
Amar Patnaik	MNIT	179	1923	10.74	22
Vijay Laxmi	MNIT	169	1266	7.49	17

(TP-Total Publications; TC-Total Citations; ACPP-Average Citations per Paper)

average citations per paper, Sambandam Anandan of NIT, Tiruchirappalli ranked first with 18.70 ACPP, followed by Arun Mohan Isloor of NITK, Surathkal with 15.83 ACPP, and SibaSankar Mahapatra of NIT, Rourkela with 13.46 ACPP ranked first to third respectively. Among the top ten authors, Arun Mohan Isloor of NITK, Surathkal and Sambandam Anandan of NIT, Tiruchirappalli, lead the table with the highest h-index recorded (h-index-33), followed by Saktiprasad Ghoshal of NIT, Durgapur with 31 h-index ranked first to third respectively. Out of the top ten authors, three belong to NIT Durgapur and MNIT Jaipur, followed by two from NIT, Tiruchirappalli and one from NIT, Rourkela and NITK Surathkal.

Most preferred collaborative institutes by NITs

Table 6 presents the top ten most preferred collaborative institutes by NITs. The Indian Institute of Technology Kharagpur was the most preferred institute with the highest, i.e. 913 collaborative research papers with various NITs, followed by the Indian Institute of Technology

Roorkee collaborated with 752 publications, and the Indian Institute of Technology Delhi collaborated with 708 publications with NITs in India. Among the top ten most preferred collaborative institutes, IIT Kharagpur has received 11,679 citations for 913 publications, followed by IIT Roorkee received 9982 citations from 752 publications and Jadavpur University has received 7958 citations for 598 publications. According to the h-index, IIT Kharagpur led the table with an h-index (41), followed by IIT Roorkee (40) and IIT Delhi (37), respectively.

Top ten most preferred international collaborative institutes by NITs

Table 7 depicts the top ten most preferred international collaborative institutes by NITs. 31 NITs have collaborations with 432 international institutions. The data reveals that the King Saud University, Riyadh, Saudi Arabia was the most preferred international institute to collaborate with NITs with 180 publications, followed by King Abdulaziz University, Jeddah, Saudi Arabia (147)

Table 6: Most preferred collaborative institutes by NITs

Name of Institution	Total Publications	Percentage (%)	Total Citations	h-index
IIT Kharagpur	913	1.31	11679	41
IIT Roorkee	752	1.08	9982	40
IIT Delhi	708	1.01	6544	37
Jadavpur University, Kolkata	598	0.86	7958	34
IISc, Bengaluru	580	0.83	7314	35
IIT Madras	453	0.65	2719	26
IIT Guwahati	424	0.61	4636	21
KIIT, Bhubaneswar	400	0.57	2719	27
IIT Bombay	399	0.57	2391	22
BARC, Mumbai	392	0.56	3543	28

and the National University of Singapore, Singapore (133) respectively. Among the top ten internationally collaborated institutes, King Saud University, Saudi Arabia, has received the highest 4912 citations (180 publications), followed by Nanyang Technological University, Singapore received 4356 citations from 109 publications and the National University of Singapore, Singapore, received 3811 citations from 133 publications.

The Nanyang Technological University received the highest 30 h-index, followed by the King Saud University with 27 h-index and the Universiti Teknologi 24 h-index ranked first to third respectively. Among the top ten international collaborated institutes by NITs, two institutes were from Malaysia, Saudi Arabia, Singapore and the United States of America, and one from Canada and South Africa, respectively.

Table 7: Most preferred International collaborative institutes by NITs

Name of the Institution	Country	Total Publications	Total Citations	h-index
King Saud University, Riyadh	Saudi Arabia	180	4912	27
King Abdulaziz University, Jeddah	Saudi Arabia	147	1717	21
National University of Singapore, Singapore	Singapore	133	3811	21
Universiti Sains Malaysia, Penang	Malaysia	116	3168	14
Universiti Teknologi Malaysia, Johor Bahru	Malaysia	110	2206	24
Nanyang Technological University, Nanyang Ave	Singapore	109	4356	30
Cameron University, Oklahoma	USA	106	149	5
University of Johannesburg, Johannesburg	South Africa	97	1477	22
Texas A&M University, Texas	USA	95	3574	21
University of Saskatchewan, Saskatoon	Canada	90	939	16

Most preferred collaborative countries by NITs

Table 8 presents the most preferred collaborative countries by NITs. NITs collaborated with 125 countries and published a total of 11,285 publications. The United States of America has emerged as the most preferred country for collaboration with 1772 publications. A total of 15.70% of the publications were found to be an international collaboration with the USA,

followed by South Korea with 714 publications (6.33 %) and the United Kingdom with 629 publications (5.57 %) ranked second to third, respectively. The papers collaborated with the USA and received 18,300 citations, followed by the United Kingdom (12478) and Saudi Arabia (10753), respectively. According to Citations per Paper, Saudi Arabia leads the table with 22.36 CPP, followed by the United Kingdom (19.84) and Canada (19.61), respectively.

Table 8: Most preferred collaborative countries by NITs

Country	Total Publications	%	Total Citations	ACPP	h-index
United States of America	1772	15.70	18300	10.33	47
South Korea	714	6.33	10221	14.32	38
United Kingdom	629	5.57	12478	19.84	40
Malaysia	531	4.71	8914	16.79	39
Saudi Arabia	481	4.26	10753	22.36	39
Germany	415	3.68	7534	18.15	28
Australia	408	3.62	7500	18.38	30
China	397	3.52	6783	17.09	34
Canada	374	3.31	7333	19.61	30
Japan	367	3.25	6059	16.51	30

(ACPP-Average Citations per Paper)

Most preferred Journals by the authors of NIT

Table 9 provides the most preferred top ten journals to publish the research papers by authors of NITs. A total of 44,311 research publications were published in journals, and the remaining publications were Conference papers, Books and Book chapters etc. The most preferred Journal to publish research papers by NITs is *RSC Advances,* with a maximum of 384 publications, followed by Materials Research Express (354 publications) and Journal of Alloys and Compounds (287 publications), first to third, respectively. However, the *International Journal of Electrical Power and Energy Systems* has received the highest (7939) citations from 231 publications, followed by *RSC Advances* received 6325 citations from 287 publications and the *Journal of Alloys and Compounds* with 4757 citations from 287 publications.

Among the top ten most preferred journals by the NITs, three journals (each) belong to Elsevier and Springer. Among their country of origin, three journals were published in the United Kingdom, two (each) from India, the Netherlands and one (each) from Switzerland, Germany and Italy. Among these top ten journals, the *International Journal of Electrical Power and Energy Systems* has the highest Impact Factor to its credit (4.418), followed by the *Journal of Alloys and Compounds* with 4.175 and *RSC Advances* with 3.049 Impact Factor ranked first to third, respectively. The Journal *International Journal of Applied Engineering Research* was the only Journal in the top ten most preferred journals which doesn't have any impact factor.

Top five highly cited papers by authors of NITs

Table 10 provides the list of the top five highly cited papers published by authors of NITs. The top five papers together received 8,360 (17.23 %) citations. The paper entitled, 'Guidelines for the use and interpretation of assays for monitoring autophagy' by Klionsky, D.J. et al. (2462 authors) published in *Autophagy journal* has received the highest citations, i.e.

Table 9: Most preferred Journals by authors of NITs

Name of the Journal	Publisher	Country	IF (2018)	Total Publications	Total Citations
RSC Advances	RSC	UK	3.049	387	6325
Materials Research Express	IOP Publishing	UK	1.449	354	831
Journal of Alloys and Compounds	Elsevier	Switzerland	4.175	287	4757
Transactions of the Indian Institute of Metals	Springer	India	1.176	279	1037
Optik	Elsevier	Germany	1.914	266	1915
Wireless Personal Communications	Springer	Netherlands	0.929	259	1268
Journal of Materials Science: Materials in Electronics	Springer	Netherlands	2.195	251	1614
International Journal of Applied Engineering Research	Research India Publications	India	NA	232	245
International Journal of Electrical Power and Energy Systems	Elsevier	UK	4.418	231	7939
Desalination and Water Treatment	Taylor & Francis	Italy	1.234	228	2314

Table 10: Top five highly Cited papers by authors of NITs

Title	Authors	Source	Volume (Issue)	Year	Citations
Guidelines for the use and interpretation of assays for monitoring autophagy (3rd edition)	Klionsky, D.J. et al. (2462 authors)	*Autophagy*	12 (1)	2016	2376
Core/shell nanoparticles: Classes, properties, synthesis mechanisms, characterization, and applications	R Ghosh Chaudhuri and S. Paria	*Chemical Reviews*	112 (4)	2012	1906
Teaching-learning-based optimization: A novel method for constrained mechanical design optimization problems	R.V. Rao; V.J. Savsani and D.P. Vakharia	*CAD Computer Aided Design*	43(3)	2011	1418
Astropy: A community Python package for astronomy	T.P. Robitaille et al. (44 Authors)	*Astronomy and Astrophysics*	558(NA)	2013	1364
A review on the utilization of fly ash	Ahmaruzzaman, M.	*Progress in Energy and Combustion Science*	36(3)	2010	1296

2376 (4.9%), where Sujit K. Bhutia of NIT Rourkela was one of the authors, followed by a paper entitled 'Core/shell nanoparticles: Classes, properties, synthesis mechanisms, characterization, and applications' published by R Ghosh Chaudhuri and S. Paria published in *Chemical Reviews* received 1906 (3.93%) citations, where both the authors belong to NIT Rourkela.

FINDINGS AND CONCLUSION

It is observed from the study that there are substantial differences in the research performance of recently established NITs vis-à-vis old NITs. As new NITs are quite young and established recently, doesn't show good research performance compared to the already established NITs. However, some of the new NITs are performing well, particularly NIT Meghalaya, NIT Goa and NIT Delhi. It also reveals that only a few NITs contributed the maximum number of research publications among the 31 NITs. NIT Rourkela, NIT Tiruchirappalli and NIT Surathkal together contributed nearly 29% of the overall publications by the NITs. The performance of NIT Srinagar and NIT Jamshedpur was significantly less though they were established in 1960 and upgraded as NIT in 2002.

The Regional Engineering Colleges (RECs) were upgraded to National Institutes of Technology (NITs) in 2002. Undoubtedly, the demand for quality technical education has increased manifold during the past few years. The conversion of these Regional Engineering Colleges into National Institutes of Technology with the status of deemed universities will positively impact the quality of technical education (The Telegraph, 2002). Earlier, these RECs were controlled by the respective states. Now, NITs are given autonomy and control over the syllabus and functioning of the institutes. It is observed from the available literature that various studies have been conducted on the research productivity of Indian Institutes of Technology for different periods. The studies also reveal that the performance of IITs compared to NITs was very high. The reasons being that some of the NITs have been established, and some have been upgraded to NITs status very recently. The financial commitments to these NITs were also less compared to IITs. Establishing an IIT would cost anywhere between 700 and 1000 crores. But in 200 crores, 17 institutes were upgraded to NITs (Goswami, 2002). The study's outcomes reveal that only a few NITs were actively publishing papers. The time is ripe for these NITs to be proactive in their research and publish quality papers in their respective fields.

ACKNOWLEDGEMENTS

REFERENCES

1. Ajiferuke, I., Burell, Q., & Tague, J. (1988). Collaborative coefficient: A single measure of the degree of collaboration in research. Scientometrics, 14(5-6), 421-433.

2. Arif, T. (2015). Analyzing research productivity of Indian Institutes of Technology. *Communications on Applied Electronics*, 1(8), 8-11.

3. Bala, A., & Kumari, S. (2013). Research Performance of National Institutes of Technology (NITS) of India during 2001-2010: A Bibliometric Analysis. *SRELS Journal of Information Management*, 50(5), 555-572.

4. Banshal, S. K., Singh, V. K., Basu, A., & Muhuri, P. K. (2017). Research performance of indian institutes of technology. *Current Science*, 112(5), 923-932.

5. Banshal, S. K., Solanki, T., & Singh, V. K. (2018). Research performance of the National Institutes of Technology in India. *Current Science*, 115(11), 2025.

6. Crawley, E. F., Malmqvist, J., Östlund, S., Brodeur, D. R., & Edström, K. (2014). *Rethinking Engineering Education: The CDIO Approach*. Springer.

7. Goswami, U.A. (2002). R & D needs more youngsters. The Economic Times (published Nov 14, 2002). Retrieved May 14, 2020 from https://economictimes.indiatimes.com/news/economy/policy/rd-needs-more-youngst ers-says-joshi/articleshow/28208239.cms?utm_source=contentofinterest&utm_mediu m=text&utm_campaign=cppst

8. Hasan, N., & Singh, M. (2015). Research output of Indian Institutes of Technology (IITs): A scientometric study. *Journal of Knowledge & Communication Management*, 5(2), 147-160.

9. Lawani, S. M. (1980). Quality, collaboration, and citations in cancer research: a bibliometric study (PhD thesis). Florida: Florida State University.

10. Ministry Of Education, GoI. (2019). *National Institutes of Technology (NITs)│Department of Higher Education*. Retrieved May 10, 2020, from https://www.education.gov.in/en/technical-education-5

11. Pradhan, B., & Ramesh, D. B. (2018). Scientometric analysis of research publications of six Indian Institutes of Technology. *Annals of Library and Information Studies*, 65(1), 50-56.

12. Pradhan, B., & Sahu, S. C. (2018). Bibliometric Analysis of Research Publications of Indian Institute of Technology (IIT's) Based on Published Literature as Reflected in Scopus. *SRELS Journal of Information Management*, 55(5), 292-298.

13. Siddaiah, D. K., Gupta, B. M., Dhawan, S. M., & Gupta, R. (2016). Contribution and citation impact of eight New IITs: a scientometric assessment of their publications during 2010-14. *Journal of Scientometric Research*, 5(2), 106-122.

14. Singh, P. K., & Singh, C. K. (2019, February). Bibliometric Study of Indian Institutes of Technology in Computer Science. In 2019 Amity International Conference on Artificial Intelligence (AICAI) (pp. 384-393). IEEE.

15. Subramanyam, K. (1983). Bibliometric studies of research collaboration: A review. *Journal of information Science*, 6(1), 33-38.

16. The Telegraph (2002). Regional Tech Colleges to be upgraded as IIT cousins. The Telegraph (published 27.06.2002). Retrieved May 14, 2020 from https://www.telegraphindia.com/india/regional-tech-colleges-to-be-upgraded-as-iit-cousins/cid/888621

17. Vijayakumar, K. (2017). A Biblometric Analysis of Collaborative Research Trends in Indian Institutes of Technology 1994. *Journal of Advances in Library and Information Science*, 6(4), 334-338.