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Scientometrics of Engineering Research at Indian Institutes of Technology Madras and Bombay during 2006-2015

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ABSTRACT

Makes an assessment of 5378 papers published by Indian Institute of Technology Madras and 4430 papers published by Indian Institute of Technology Bombay respectively indexed by the Scopus database in the field of Engineering Sciences and its sub-field during 2006–2015. The study indicates that the number of papers grew during the period of study. The findings indicate that the researchers of both the IITs in the field of engineering sciences published their papers in global journals published from USA, UK and Germany and other countries of the West. Around 19.66% papers published by IITM scientists and 26.54% papers published by IITB scientists in engineering sciences during 2006–2015 remained uncited. More authors from IITB were highly cited as compared to IITM.

Keywords: Engineering science, scientometrics, citation analysis, impact factor

1. INTRODUCTION

Explores the research output of Indian Institute of Technology, Madras (IITM) and Indian Institute of Technology, Bombay (IITB) in the area of engineering sciences during 2006-2015. IITB was established in 1958 with the assistance of the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the former Soviet Union. It has an extensive graduate program offering doctoral degrees in Science, Technology, Engineering and Mathematics. Currently IITB has a total of 14 academic departments, six centers, one school, and three interdisciplinary programmes. Over the last 53 years, around 39,000 engineers and scientists have graduated from the institute.

IITM is one among the foremost institutes of national importance in higher technological education, basic and applied research. It was established in 1959 with the assistance of the Federal Republic of Germany to provide education and research facilities in engineering and technology. These two IITs are the oldest IITs after IIT Kharagapur and produce major chunks of innovative ideas and publications. It will be interesting to know the actual productivity of two IITs and to know which of the two IITs have more impact on national and international level in terms of publication output and their impact in terms of citations. The study is based on the papers indexed by Elsevier's *Scopus* database from 2006-2015. Scientometric indicators used in the study have been explained in the succeeding paragraphs.

2. OBJECTIVES

The objectives of the study are to:

(a) Identify the type of documents used for communicating research results

(b) Examine the pattern of growth of the output

(c) Examine the communication pattern of the two institutes in terms of publishing country of journals and the impact factor of these journals

(d) Identify the sub-areas of engineering sciences in which the research results were published

(e) Identify most prolific authors

(f) Investigate the distribution of citation pattern and to identify highly cited authors.

3. LITERATURE REVIEW

Review of related literature is a part and parcel of any research investigation which empowers the investigator to make out the prior research interests, research patterns and the significance of the research output in a field of knowledge. In various fields including science and engineering, few studies have been reported in literature which analysed the scientific output of institutions. For instance, Prathap & Gupta[1] analysed the research performances of Indian Engineering and technological institutes for the period 1999-2008, which shows how these institutes acts as generators of new knowledge in the higher education sectors of India. Singh[2] analysed the research publications of Indian Institute of Technology

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Kharagpur (IIT KGP) published during 1990 to 2014, indexed in Web of Science (WoS). The pattern of growth of total papers showed an increasing trend (except in 2012) and slow growth in some years. It was also observed that collaboration among researchers increased during the period of study. Material science, engineering, physics and chemistry were the major research areas of IIT KGP. Baby & Kumaravel[3] analysed the research productivity of Periyar University indexed in *Scopus* from 1998 to 2010 for a period of 13 years. Jeevan & Gupta[4] suggest a methodology for studying the quantitative profile of a research university, with a view to get an idea about the performance and impact of research produced in each department, and the comparison of the impact of research in various departments. Singh, Gupta & Kumar[5] studied research contributions and impact of research in Indian Institute of Technology, Roorkee. Bhatia; Rao & Saiyed[6] studied research trends in a premier institute based on annual reports for a period of 25 years. Dhawan & Gupta[7] analysed physics research in India in terms of broad characteristics of India's physics publications output, its subject areas of strength and also the extent to which country's research pursuits have technological orientation. The results shows that out of 435 institutions participating in physics research, just 20 had accounted for 50 per cent of the total output. The academic sector, being the biggest of all the sectors in terms of participating institutions, made the largest contributions to the physics output, followed by R&D sector, industrial sector, and government sector. Balasubramani & Parameswaran[8] analysed the growth and the contribution of research carried out by the scientists of Banaras Hindu University (BHU) in terms of pattern of communications of authors and scattering of their research output in different journals, analysis of the strong and weak areas of university research. The results shows that the annual average research output of BHU was 578 records and the research output of the scientists is fairly collaborative with foreign authors. "*Current Science*" is one of the most preferred journals of the authors of BHU. Singh[9] analysed the research performance of Indian Institute of Technology, Delhi in terms of publications, Collaboration and international participation and major research areas of study. Physics, Mathematics and Material science are the top research areas of IIT Delhi. Singh; Uddin & Pinto[10] analysed the Computer Science research in top 100 institutions in India and in the world during last 25 years period (1989–2013). It involves analysis along traditional scientometric indicators such as total output, citation-based impact assessment, co-authorship patterns, international collaboration levels, etc. The key contribution of the experimental work is that it's an analytical characterisation of its kind, which identifies characteristic similarities and differences in CS research landscape of Indian institutions vis-à-vis world institutions. Uddin & Singh[11] analysed the framework and experimental results on a quantity–quality composite performance assessment and ranking of 100 Indian institutions in computer science (CS) research. Bornmann[12], *et al*. analysed the ranking and mapping of universities and research-focused institutions worldwide. The web application presented in this paper allows for an analysis to reveal centers of excellence in different fields worldwide using publication and citation data. The URL of the web application is as follows: http://www.excellencemapping.net.

Present study intend to diagnose the literature growth; sources of publication; authorship pattern and prolific authors and journals; collaborative efforts by the authors of IIT Madras and IIT Bombay.

4. DATA AND METHODOLOGY

The data for the study was downloaded from *Scopus* database for the period 2006-2015 using the following search strategy: (AF-ID ("Indian Institute of Technology Bombay" 60014153) AND (LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009) OR LIMIT-TO (PUBYEAR, 2008) OR LIMIT-TO (PUBYEAR, 2007) OR LIMIT-TO (PUBYEAR, 2006)) AND (LIMIT-TO (SUBJAREA , "ENGI")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") OR LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "ch") OR LIMIT-TO (DOCTYPE, "no") OR LIMIT-TO (DOC TYPE, "le")). Similar strategy was used to download data for IITM.

The method of complete counting has been used to analyse the data. Under this method each author is credited with one count for every publication that bears his/her name regardless of whether it is a single-authored or multiple-authored publication. This results in inflation of publication and citation data. Bibliographic details downloaded consisted name of author(s) with his/her affiliation, document title, year, source title, volume, issue, pages, citation count, source and document type, name of the publisher, and language of original document. The data downloaded was analysed using MS-Excel as per the objectives of the study.

5. BIBLIOMETRIC INDICATORS USED

We have used the Total Number of Publications (TNP); Total Number of Citations (TNC); Citations per Paper (CPP); and Relative Citation Impact (RCI) as measures of output and impact. TNP and TNC are absolute indicators, while CPP and RCI are relative indicators. The values of TNP and TNC were directly obtained from the downloaded data. CPP is the average number of citations per paper (C/P). It has been widely used in bibliometric studies to normalise a large disparity in volumes of published output among disciplines, countries and institutions for a meaning full comparison of research impact. RCI is a measure of both the influence and visibility of a nation's research in global perspective. It is defined as "a country's share of world citations in

the subspecialty/country's share of world publications in the subspecialty". RCI = 1 denotes a country's citation rate equal to world citation rate; RCI < 1 indicates a country's citation rate less than world citation rate and also implies that the research efforts are higher than its impact; and RCI > 1 indicates a country's higher citation rate than world's citation rate and also imply high impact research in that country. Here CPP and RCI have been used for a meaning comparison of the impact of the research output for different sub-disciplines and the two IITs under study. These indicators have been used by Dwivedi[13], *et al*. for assessment of organic chemistry research in India (add this in reference list). The h-index suggested by Hirsch has been used to rank the prolific authors. The h-index of a scientist is [h] if [h] among his/her [N] articles have at least [h] citations each and other (i.e., remaining [N-h]) articles have fewer than h citations each. An h-index, say, of 10 of a scientist means that among all the articles published by the scientist have received at least 10 citations each[14].

6. RESULTS AND DISCUSSION

6.1. Research Results Communicating Documents

During 2006-2015, the researchers from IITM published 5378 papers and the researchers from IITB published 4430 papers on various aspects of engineering sciences in different type of document sources. The selection of an appropriate outlet often has an influence on the visibility and impact of a research article. Hence, analyses of the types of document used for communicating research results are very important. The results of the analysis on the document types are given in Table 1. It indicates that the academicians from both the institutes preferred to publish their research results in journals. However, scientists of IITB have much higher share of conference papers as compared to IITM. One possible reason for this may be that the researchers want their results to be noticed by the professionals as early as possible, because publishing in journals take longer than conference papers. Also in the discipline of engineering sciences conferences are considered as important as the research articles in journals.

Table 1. Format used for communicating research results

Document type	IITM (%)	IITB (%)
Article	3408 (63.4)	2397 (54.1)
Conference paper	1856 (34.5)	1917 (43.3)
Review	61 (1.1)	57 (1.3)
Book chapter	46 (0.9)	48 (1.1)
Letters	4 (0.1)	8 (0.2)
Notes	3 (0.1)	3 (0.1)
Total	**5378**	**4430**

6.2. Growth Pattern of Output

Figure 1 depicts the absolute output of IITM and IITB during 2005-2015. It indicates that in the initial years the output is low, but in the later periods the output of both institutes has grown continuously reaching a peak in the year 2014 with a slight decline for IITM in the year 2011. The low output in 2015 for both the institutes may be that some papers published in journals appearing late might have not been included in the output. The Compound Annual Growth Rate (CAGR) calculated by using the formula available at www.investopedia.com/calculator/cagr.aspx was found to be 4.4 for IITM and 6.4 for IITB.

6.3. Disciplines of Research and Distribution of Citations

The total output was classified into to eight sub-disciplines. Table 2 provides the data on the total number

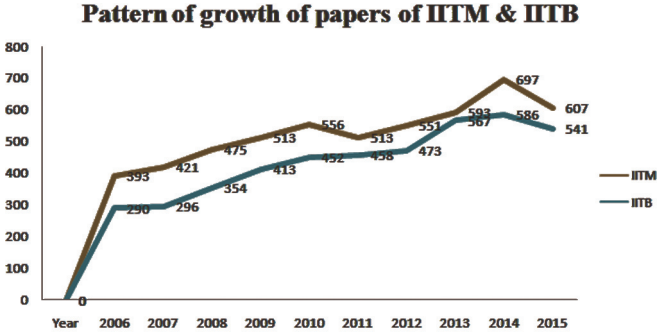

Figure 1. Pattern of output of IITM and IITB during 2005-15.

Table 2. Disciplines of research and distribution of citations

Discipline	IITM				IITB			
	TNP	TNC	CPP	RCI	TNP	TNC	CPP	RCI
Material science	1481	10220	6.91	1.01	1163	8217	7.03	0.97
Physics & astronomy	1147	7618	6.64	0.97	845	6037	7.14	0.85
Computer science	1079	5344	4.95	0.72	979	6064	6.19	0.98
Chemical engineering	590	5706	9.67	1.44	429	4023	9.35	1.31
Mathematics	442	2189	4.95	0.73	339	2245	6.62	0.93
Chemistry	307	2940	9.57	1.40	241	2021	8.38	1.17
Environmental science	209	1643	7.86	1.16	239	1846	7.72	1.11
Earth & Planetary science	123	325	2.64	0.39	195	1090	5.58	0.54
Total	**5378**	**35985**	**6.69**		**4430**	**31543**	**7.12**	

of publications (TNP), total number of citations (TNC) obtained by each discipline along with the values of Citation per Paper (CPP) and Relative Citation Impact (RCI) for different sub-areas of engineering sciences research. The average value of CPP for the entire output for IITM is 6.69, while for IITB it is 7.12. This indicates that papers published by IITB had a higher impact value than IITM in terms of CPP. Among all the sub-disciplines, the value of CPP was less than average for earth and planetary sciences, mathematics and computer science for IITM. Lowest value of CPP was for earth and planetary sciences. The values of RCI also followed similar trends for various sub-fields. Like IITM, the value of CPP was lowest for earth and planetary sciences. However, for other sub-disciplines the value of CPP was close to the average unlike IITM. The RCI values for IITB also show identical movements like the CPP for various sub-disciplines.

6.4. Information Dissemination Pattern of Researchers

To know the information dissemination pattern of two IITs researchers' two distinctive parameters were undertaken, namely the journal publishing county and the impact factor (IF) of the journals used for communicating the research results. Papers published in higher IF journals signify more impact than papers published in low IF journals. Also, journals published from the advanced countries, command more respect and prime channel connectedness as distinguished to journals published from India or other developing countries. The findings based on these two parameters have been narrated below.

6.5. National vs. Global Journals

The scientists of IITM published their papers in 771 journals published from 31 countries including India and the scientists of IITB published their papers in 593 journal titles published from 29 different countries including India. Distribution of papers published in journals originating from different countries has been presented in Table 3. It indicates that about 33.48% papers by the scientists of IITM and 39.25% papers by IITB were published in journals originating from the USA. The number of papers published in journals from UK was almost the same for both IITM and IITB. The share of papers published by the authors of two institutions in journals published from India was 6.27% and 4.42% respectively by both the institutions. This illustrates that more than three fourth of the papers by the scientists from the two IITs were published in journals originating from the advanced countries of the West namely the USA, the UK, The Netherlands and Switzerland. This indicates that the research results published by the scientists are well connected to the mainstream science. This substantiates the finding of Nagaiah and Srimannarayana[15] that Indian scientists prefer to publish in global journals.

6.6. Scattering of Papers According to Impact Factor

To ascertain the scattering of papers according to impact factor authors have classified impact factor into four categories. These are 0–1 (low), >1 to ≤ 3 (medium), > 3 to ≤ 5 (high) and > 5 (very high). Distribution of output according to the magnitude of impact factor is given in Table 4. It indicates that about 17% papers by the scientists of IITM and 14.4% papers by the scientists of IITB were published in low impact factor journals. About two-third of the papers by both IITs were published in medium IF journals. However, the number of papers in high and very high impact factor journals for IITB is slightly higher than the IITM. Based on this criterion,

Table 3. Dispersal of IITM and IITB output by journal publishing countries

Journal Publishing Countries	IITM		IITB	
	TNP (%)	No. of Journals	TNP (%)	No. of Journals
USA	1141 (33.48)	256	941 (39.25)	213
UK	1015 (29.78)	218	657 (27.40)	181
Netherlands	638 (18.72	104	435 (18.14)	94
India	214 (6.27)	21	106 (4.42)	19
Germany	148 (4.34)	30	36 (1.50)	16
Switzerland	77 (2.26)	8	44 (1.83)	7
South Korea	44 (1.29)	13	24 (1)	9
Singapore	22 (0.65)	6	54 (2.25)	6
China	18 (0.53)	13	17 (0.7)	6
Japan	13 (0.39)	10	30 (1.25)	11
Sub total	**3330 (97.71)**	**679**	**2344 (97.78)**	**562**
Other 21 countries	78 (2.29)	38	53* (2.21)	31
Total 31 countries	3408 (100)	717	2397** (100)	593

*Other 19 countries; **Total 29 countries

Table 4. Distribution of output according to Magnitude of Impact Factor of journals

Magnitude of IF	IITM		IITB	
	TNP	% TNP	TNP	% TNP
0-1 (Modest)	914	16.99	562	14.33
>1≤ 3 (Standard)	3698	68.76	2906	67.74
>3 ≤ 5 (high)	730	13.57	731	16.51
>5 (very high)	36	0.66	63	1.42
Total	**5378**	**100**	**4430**	**100**

one can conclude that the papers published by both the IITs is linked to the main stream science as more than four-fifth of the published papers appeared in medium and high impact factor journals.

6.7. Most Common Journals Used for Publishing Research Rsesults

Journals are regarded as one of the primary sources of information which has become the fastest and most effective means of disseminating research findings. A higher emergence rate of periodicals in a subject field can be a measure of the growth of knowledge in that field. It is an accepted fact that in the field of science there is apparently an increasing rate of emergence of new journals to meet the rapid explosion of information. Table 5 lists most common journals used by the two IITs. It indicates that of the 21 most common journals used for communicating research results, four were common journals used for publishing research results by both the IITs. These four journals were *International Journal of Heat and Mass Transfer, Industrial and Engineering Chemistry Research*, *Journal of Alloys and Compounds* and *Journal of Nanoscience and Nanotechnology*. These four journals together published 146, 122, 89 and 86 papers respectively. The most common journals used for publishing research results were published from advanced countries of the West except two, namely *Journal of Structural Engineering* Madras and *Indian Concrete Journal*, which were published from India.

6.8. Most Prolific Authors and the Impact of their Research Output

A total of 2004 authors from IITM contributed to the total output of 5378 papers published during the study period whereas 2017 authors from IITB contributed to the total output of 4430 papers published during that period. 18 authors from IITM and 19 scientists from IITB contributed more than 50 papers to the total output. These constituted 1179(21.93%) papers of IITM and 1319(29.78%) papers for IITB. Of the 37 authors from both the IITs 12 were from the department of electrical engineering and six from the department of mechanical

Table 5. List of most prolific journals

IITM	TNP	IF*	Journal publishing Country
International Journal of Heat and Mass Transfer	106	2.4	England
Industrial and Engineering Chemistry Research	56	2.6	USA
Materials Science and Engineering A	54	2.6	USA
Journal of Alloys and Compounds	52	3.0	Netherlands
Journal of Structural Engineering Madras	50	0.0	India
Metallurgical and Materials Transactions A	44	1.7	Germany
Materials and Design	43	3.5	Netherlands
Journal of Sound and Vibration	43	1.8	USA
Journal of Nanoscience and Nanotechnology	42	1.6	USA
Indian Concrete Journal	41	0.0	India
International Journal of Advanced Manufacturing Technology	35	1.5	UK
Materials and Manufacturing Processes	35	1.6	UK
Applied Mechanics and Materials	34	0.2	Germany
IITB			
Industrial and Engineering Chemistry Research	66	2.6	USA
IEEE Transactions on Electron Devices	54	2.5	USA
Journal of Nanoscience and Nanotechnology	44	1.6	USA
International Journal of Heat and Mass Transfer	41	2.4	Italy
Geotechnical Special Publication	40	0.0	USA
Journal of Alloys and Compounds	37	3.0	Netherlands
Nuclear Engineering and Design	33	0.9	Switzerland
IEEE Electron Device Letters	32	2.8	USA
Journal of Process Control	31	2.7	UK

Table 6. Most prolific authors and their citation impact

S. No.	Authors	Department	IITs	TNP	TNC	CPP	h-Index
1.	Agarwal, V.	Electrical Engg.	IITB	109	2027	18.59	18
2.	Bandyopadhyay, B.	Systems & Control Engg.	IITB	101	667	6.61	15
3.	Rao, V.R.	Electrical Engg.	IITB	88	854	9.71	17
4.	Merchant, S.N.	Electrical Engg.	IITB	80	156	1.95	6
5.	Verma, A.K.	Electrical Engg.	IITB	74	317	4.29	7
6.	Desai, U.B.	Electrical Engg.	IITB	73	157	2.15	6
7.	Baghini, M.S.	Electrical Engg.	IITB	73	215	2.95	8
8.	Joshi, S.S.	Mechanical Engg.	IITB	69	776	11.24	13
9.	Agrawal, A.	Mechanical Engg.	IITB	67	883	13.17	16
10.	Fernandes, B.G.	Electrical Engg.	IITB	67	569	8.49	13
11.	Mahapatra, S.	Electrical Engg.	IITB	64	893	13.95	15
12.	Patwardhan, S.C.	Chemical Engg.	IITB	62	700	11.29	16
13.	Chakrabarti, S.	Electrical Engg.	IITB	59	121	2.05	6
14.	Prabhu, S.V.	Mechanical Engg.	IITB	59	586	9.93	13
15.	Jangid, R.S.	Civil Engg.	IITB	59	729	12.35	16
16.	Srividya, A.	Computer Science & Engg.	IITB	57	282	4.94	6
17.	Gumaste, A.	Computer Science & Engg.	IITB	55	105	1.91	7
18.	Bahadur, D.	Metalluegy & Material Engg.	IITB	53	647	12.21	14
19.	Mukherjee, J.	Electrical Engg.	IITB	50	164	3.28	6
20.	Murty, B.S.	Metallurgy & Material Science	IITM	100	1007	10.07	17
21.	Basak, T.	Chemical Engg.	IITM	91	1214	13.35	19
22.	Mishra, M.K.	Electrical Engg.	IITM	88	774	8.79	16
23.	Rao, B.N.	Civil Engg.	IITM	79	342	4.32	11
24.	Balasubramaniam, K.	Chemical Engg.	IITM	73	537	7.35	14
25.	Sujith, R.I.	Aerospace Eng	IITM	69	482	6.98	12
26.	Pavan, S.	Electrical Engg.	IITM	67	554	8.26	14
27.	Sundararajan, T	Mechanical Engg.	IITM	63	669	10.61	12
28.	George, B.	Electrical Engg.	IITM	62	228	3.67	7
29.	Das, S.K.	Mechanical Engg.	IITM	59	880	14.91	15
30.	Balaji, C.	Mechanical Engg.	IITM	58	621	10.71	15
31.	Roy, S.	Mathematics	IITM	56	1137	20.31	19
32.	Kamaraj, M.	Metallurgy & Material Science	IITM	55	415	7.54	12
33.	Ganesan, N.	Mechanical Engg.	IITM	55	937	17.03	16
34.	Swarup, K.S.	Electrical Engg.	IITM	52	799	15.36	16
35.	Sarathi, R.	Electrical Engg.	IITM	51	242	4.74	10
36.	Giridhar, K.	Electrical Engg.	IITM	51	159	3.11	7
37.	Velmurugan, R.	Aerospace Engg.	IITM	50	441	8.82	14

engineering. Thus, about half the prolific authors belonged to these two departments. Among all the 37 authors, Agarwal, V. of IITB, Roy, S., Ganesan, N. and Swaroop, K.S. of IITM had highest CCP values.

6.9 Citation Analysis of Output

Citation analysis addresses the problem of measuring the impact of research output. It assumes that the greater the impact of a particular publication, the more frequently it will be cited in the scientific literature. Citation counts of authors or a group of authors or an institution is an indication of the influence or visibility of individuals or groups or institutions. Noteworthy citations to a scientific publication have been elucidated as symbol of scientific supremacy. An author's perceptibility can be deliberated through a calculation of how frequently their publications have been cited in other publications. The consequences of research can thus be appraised by building citation counts of the articles received over a period of time.

Table 7 depicts the distribution of citations acquired

Table 7. Distribution of citations

Extent of	ITM		IITB	
Citations	TNP (%)	TNC	TNP (%)	TNC
0.	1187 (19.66)	0	1176 (26.54)	0
1.	710 (15.61)	710	780 (17.60)	550
2.	445 (8.28)	890	367 (8.29)	734
3.	325 (6.04)	975	275 (6.21)	825
4.	241 (4.48)	964	225 (5.08)	900
5.	202 (3.76)	1010	175 (3.96)	875
6.	170 (3.16)	1020	137 (3.09)	822
7.	177 (3.29)	1239	111 (2.51)	777
8.	226 (4.21)	1008	89 (2.01)	676
9.	110 (2.04)	990	93 (2.09)	837
10.	225 (4.18)	2250	84 (1.89)	840
11-20.	648 (12.04)	4642	462 (10.43)	4440
21-30.	210 (3.90)	5154	150 (3.39)	3642
31-40.	208 (3.89)	3736	145 (3.28)	3075
41-50.	145 (2.70)	2845	64 (1.45)	2051
51-100.	125 (2.33)	4553	66 (1.48)	4541
100>	24 (0.45)	3999	31 (0.69)	5958
Total	**5378**	**35985**	**4430**	**31543**
CPP	**6.7**		**7.1**	

by papers during 2006-2015. Out of the total papers published by scientists of IITM, about one-fifth (19.66%) of the papers did not get any citation and the rest 80.33% were cited one or more times. Out of the total cited papers about (35.75%) were cited between 1-5 times and 16.88% were cited 6-10 times. Thus, about half (53%) of the papers were cited between 1-10 times. Rest (27%) was cited more than 10 times. Out of the total papers published by scientists of IITB, one-fourth (26.54%) of the papers did not get any citation and the rest 73.45% were cited one or more times. Out of the total cited papers around (41.12%) were cited between 1-5 times and 11.61% were cited 6-10 times. Thus, about (52.73%) of the papers were cited between 1-10 times. Rest (20.72%) was cited more than 10 times. Based on the pattern of citations also, one can conclude that the scientific output of both the IITs in engineering sciences is well connected to the mainstream science as more than two third of the papers were cited in the international literature.

6.10. Highly Cited Authors

Table 8 presents 14 highly cited papers which obtained 175 or more citations. Out of 14 highly cited authors 10 authors belonged to IITB and only 4 authors to IITM. Of the highly cited authors most of the papers were multi authored and authored in international collaboration. These 14 papers draw 3% of all the citations. It indicates that the manuscripts published by scientists of IITB made more impact as compared to papers published by the authors from IITM. This is also indicated by the pattern of citation per paper (CPP) for the two IITs.

Table 8. Highly cited authors from the two IITs

S. No.	Authors and Bibliographic Details	TNC	Institute
1.	Ruparelia, J.P.; Chatterjee, A.K. & Duttagupta, S.P. *Acta Biomaterialia*, **4**(3) 2008, 707-16.	437	IITB
2.	Alam, M.A., Mahapatra, S., *Microelectronics Reliability*, **45**(1) 2005, 71-81.	416	IITB
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7. CONCLUSIONS

Although the annual rates of growth is inconsistent during the period of study, but the productivity grew

continuously throughout the study period. Highest numbers of papers were published in the discipline of material science by scientists of both the IITs with highest influence in terms of CPP and RCI. From the angle of the distribution of published papers in journals by country, the scientists of both the IITs prefer to publish their papers in journals published from the advanced countries of the West. More number of papers published by researchers from IITB was highly cited as compared to IITM.

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