



# Mapping of Research Publications and Patents Portfolio of Top 100 NIRF Engineering Institutes in India

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**Abstract** - Research publications and patents (granted) are two important indicators for judging the Science, Technology and Innovation ecosystem of a nation. India enjoys an impressive global ranking of 5 in the indicator of research publications as per Global Competitive Index, 2017. However, its patent applications filing is very poor viz a viz many countries including Asian countries like China, Japan and S. Korea which filed 13,38,503; 3,18,381 and 1,08,830 patent application reported by World Intellectual Property Organization, 2017. In order to boost the patent ecosystem in India, it is imperative to understand the patents and publication portfolio of Higher Education Institutes of India. In the present study, top 100 National Institutional Ranking Framework Engineering Institutes were mapped for research publications and patents (granted), in order to identify institutes performing well in domains of research publications, or patents or both. The study revealed that only a handful of institutes namely, Indian Institute of Technology (IIT)-Bombay, IIT-Madras, IIT-Delhi and IIT-Kanpur are performing satisfactorily in the domains of research article publications as well as patent generation. However, a large number of engineering institutes such as National Institutes of Technology, autonomous institutes/colleges and universities are good in the publication of research articles but have not been able to make a niche in the domain of patent generation. This limitation is being attributed to the lack of or absence of 'Translational Research Ecosystem' in their respective institutes. The translational research ecosystem of IITs can be adopted by other institutes to strengthen their patent regime. The data was also categorized on the basis of fields of specialization. The results showed that IITs are leading not only in the fields of Engineering but also have good profile in the fields of Chemical Engineering, Physics, Pharma/Drug Biotech/Food/Agriculture and Medical Sciences.

**Keywords**— Engineering, IIT, NIT, Publications, Patents, Translational Research Ecosystem

## I. INTRODUCTION

The 21<sup>st</sup> century is considered to be the era of knowledge and innovation in which patents and research publications occupy prominent positions as the global indicators for ranking of the world economies. Research articles reflect the academic excellence, whereas patents reflect the ability to translate fundamental research into a product/technology for commercial or societal benefits. By global standards, India's performance in publishing research articles is impressive and has been ranked among the top 5 countries in the indicator of research publications [1], but on the other hand, in terms of intellectual property rights, India fairs poorly with 45<sup>th</sup> global ranking [2]. India's record of 'Patent applications filing' is a cause of concern as it filed and processed only 45,057 patents as compared to other countries such as China (13,38,503), USA (8,05,571); Japan (3,18,381) and S. Korea (1,08,830) [3]. This data is indicative of the fact that Indian scientists are more inclined towards research publications and pay less attention to convert their academic excellence into innovative products/technologies. Of late, the Indian government is planning to prepare a roadmap for stimulating translational research in the Higher Education Institutes (HEIs), for generation of more patents, which can be licensed out to industry for economical and societal gains. The Indian Higher Education system is composed of over 900 institutes comprising of 837 universities and 91 Institutes of National Importance (INIs) including Indian Institutes of Technology (IITs) and National Institutes of Technology (NITs). The first and foremost step in this direction is to map HEIs for their number of research publications and patents. Such a study will yield important data about institutes excelling in translational research, which can act as models for institutes producing only large number of research publications but generate less or no patents.

The Department of Science and Technology (DST)-Centre for Policy Research (CPR) at Panjab University (PU), Chandigarh undertook a task of mapping the publications and patent profiles of top 100 engineering institutes in accordance with National Institutions Ranking Framework (NIRF) published in 2016 [4]. NIRF is published by Ministry of Human Resource and Development (MHRD), Government of India to rank the Indian Institutions of Higher Education on the basis of quality of education and research.



## II. MATERIAL &amp; METHODS

## Data Collection:

A. *Publications*: The research articles publication data of universities was retrieved from Scopus [5] owned by Elsevier [6]. Scopus is the largest abstract and citation database of peer-reviewed literature: scientific research articles, books and conference proceedings. For our study, we have considered only research articles publications.

B. *Patents*: The raw data for patents (granted) of universities was procured from a well reputed private firm, Talwar & Talwar (TT) Consultants located in Mohali, Punjab, India. Data extraction has been done by using following patents' search tools, which guarantees 80-90% accuracy for the patent data.

- XLPAT owned by TT Consultants [7]
- Indian Patent Advanced Search System (InPASS) of Govt. of India (GoI) [8]
- Orbit owned by Questel [9]
- Derwent Innovation owned by Clarivate Analytics [10]

It is pertinent to mention that, the data extracted for the patents is on the basis of university/institute as applicant which means the patent is owned by the university/institute. The patents' data was not procured based on the 'names of the inventors' as applicant has the exclusive rights to commercially exploit the invention. In the present study, only patents (granted) category was included. Patents (filed) category was not considered as many universities, especially private universities, and individual scientists file patents without getting them examined thoroughly for patentability criteria (novelty, industrial application and non-obviousness) by the competent patent attorneys, and subsequently gets rejected by the Patent Office during scrutiny process. Such patents are filed either to improve the branding of the institutes or for individual gains such as boosting curriculum vitae to seek promotion in their professional career.

*Time Span for the Study*: For the purpose of this study, data for research articles' publications and patents (granted) was collected for the time period 2010-16. The time span of 7 years is considered enough to analyse trends on parameters of articles' publications and patents of the universities.

## III. RESULTS

The data pertaining to research publications and patents (granted) of top 100 NIRF engineering institutes in India was analysed to identify institutes having good, moderate or poor performance. The study was further extended to analyse universities excelling in various subject domains like Engineering, Chemical Engineering, Physics, Biotech/Food/Agriculture, Medical Sciences and Pharma/Drug.

## ➤ Composite Analysis

Top 100 NIRF engineering institutes comprised of a) INIs (42) categorized as IITs (16), NITs (22), Indian Institute of Science Education and Research (IISER; 1), Indian Institute of Information Technology, Design and Management (IIITDM;

2) and Indian Institutes of Engineering Science and Technology (IIEST; 1), b) Autonomous Institutes and Colleges (AICs) (35), universities (20) and university departments (3) (Fig. 1).

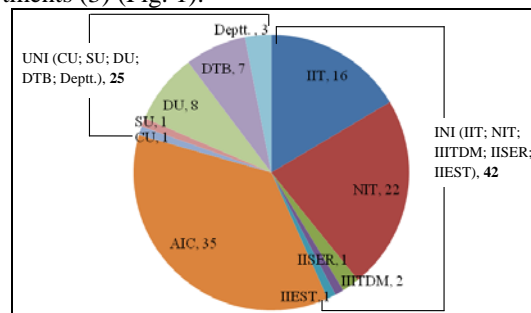


Fig. 1 Categorization of Top 100 NIRF Engineering Institutes in India  
INI: Institute of National Importance; IIT: Indian Institute of Technology; NIT: National Institute of Technology; IISER: Indian Institute of Science Education and Research; IIITDM: Indian Institute of Information Technology, Design and Management; IIEST: Indian Institutes of Engineering Science and Technology; AIC: Autonomous Institute/College; DU: Deemed University, D-T-B: Deemed to be University; SU: State University; CU: Central University.

Based on the number of research publications (period: 2010-16), top 10 NIRF engineering institutes comprised of 8 IITs; one central university and one NIT (Fig.2). During this period of study, 27 institutes comprising of 17 INIs (10 IITs and 7 NITs); 6 universities (1 central university, 2 state universities; 2 deemed universities and one deemed to be university), 4 Autonomous institutes/colleges (3 public institutes and one private institutes) published >100 research publications per year (Table 1). Nearly half of these institutes (14) published > 200 research articles on annual basis. Government of India has set up 23 IITs and 16 of them were ranked in top 100 NIRF engineering institutes, 2016. Interestingly, top 8 ranks were occupied by IITs, followed by Jamia Millia Islamia (JMI), New Delhi a central university and by NIT, Rourkela (NIT-R). All top 8 ranked IITs were first generation IITs (established between 1950-94). IIT, Kharagpur (IIT-KGP) was ranked number one (8724) followed by IIT, New Delhi (IIT-D; 7148); IIT, Madras (IIT-M; 6440); IIT, Bombay (IIT-B; 6300); IIT, Roorkee (IIT-R; 6028); IIT, Kanpur (IIT-K; 5622) and IIT, Hyderabad (IIT-H; 5398).

The ranking of institutes based on patents (granted) showed that only 23 of the top 100 NIRF engineering institutes are holders of patents (granted) during the time period 2010-16 (Table 1). The study also revealed that only 6 institutes have 10 or more patents (granted). IIT-B led in this category with 100 patents (granted) followed by IIT-D (56), IIT-M (48) and IIT-K (44) (Fig.3). There was a big gap between fourth and fifth ranked institutes i.e. IIT-K and Manipal Institute of Technology (MIT), Manipal, a private institute with 13 patents (granted). Fifteen institutes held single digit number of patents (granted). Nine patents (granted) were held by Amrita Vishwa Vidyapeetham (AVV), Ettimadai, 5 by Thiagarajar College of Engineering (TCE), Coimbatore, 4 by University Institute of Chemical Technology (UICET), Coimbatore and 3 by Vellore Institute of Technology (VIT), Vellore. Twelve institutes were holding either one or two patents (granted) (Table 1).



**Table 1: Research Articles and Patenting Profile of Top 100 NIRF Ranked Engineering Institutes in India**

S. No.	Institute	Year of Establishment	Institute Status	Public/Private Status	Ranking/# of Res. Articles	Ranking/# of Patents Granted	Ranking/# of Patents Published
1.	Indian Institute of Technology (IIT), Kharagpur (IIT-KGP) ( <a href="http://www.iitkgp.ac.in">www.iitkgp.ac.in</a> )	1950	INI (IIT)	Public	1/ 8724	6/ 10	5/ 171
2.	IIT, Delhi (IIT-D) ( <a href="http://www.iitd.ac.in">www.iitd.ac.in</a> )	1961	INI (IIT)	Public	2/ 7148	2/ 56	4/ 208
3.	IIT, Madras (IIT-M) ( <a href="http://www.iitm.ac.in">www.iitm.ac.in</a> )	1959	INI (IIT)	Public	3/ 6440	3/ 48	2/ 376
4.	IIT, Bombay (IIT-B) ( <a href="http://www.iitb.ac.in">www.iitb.ac.in</a> )	1958	INI (IIT)	Public	4/ 6300	1/ 100	1/ 441
5.	IIT, Roorkee (IIT-R) ( <a href="http://www.iitr.ernet.in">www.iitr.ernet.in</a> )	1846 (2001)	INI (IIT)	Public	5/ 6028	12/ 1	11/ 25
6.	IIT, Kanpur (IIT-K) ( <a href="http://www.iitk.ac.in">www.iitk.ac.in</a> )	1959	INI (IIT)	Public	6/ 5622	4/ 44	3/ 252
7.	IIT, Hyderabad (IIT-H) ( <a href="http://www.iith.ac.in">www.iith.ac.in</a> )	2009	INI (IIT)	Public	7/ 5398	11/ 2	10/ 26
8.	IIT, Guwahati (IIT-G) ( <a href="http://www.iitg.ernet.in">www.iitg.ernet.in</a> )	1994	INI (IIT)	Public	8/ 4205	0	13/ 23
9.	Jamia Millia Islamia (JMI), New Delhi ( <a href="http://jmi.ac.in/">jmi.ac.in/</a> )	1920	UNI (CU)	Public	9/ 2320	0	20/ 10
10.	National Institute of Technology (NIT), Rourkela, Orissa (NIT-R) ( <a href="http://www.nitrkl.ac.in">www.nitrkl.ac.in</a> )	2002 (1960)*	INI (NIT)	Public	10/ 2275	0	24/ 6
11.	Thapar University (TU), Patiala ( <a href="http://www.thapar.edu/">http://www.thapar.edu/</a> )	1956	UNI (D-T-B)	Private	11/ 2269	0	20/ 10
12.	Birla Institute of Technology (BIT), Ranchi ( <a href="https://www.bitmesra.ac.in/">https://www.bitmesra.ac.in/</a> )	1955	UNI (DU)	Private	12/ 1958	0	18/ 12
13.	Coimbatore Institute of Technology (CIT), Coimbatore ( <a href="http://www.cit.edu.in/">www.cit.edu.in/</a> )	1956	AIC	Public	13/ 1854	0	28/ 2
14.	Cochin University of Science & Technology (CUST), Cochin ( <a href="http://www.cusat.ac.in/">www.cusat.ac.in/</a> )	1971	UNI (SU)	Public	14/ 1656	12/ 1	23/ 7
15.	Amrita Viswa Vidyapeetham (AVV), Ettimadai ( <a href="http://www.amrita.edu/">http://www.amrita.edu/</a> )	2003	UNI (SU)	Private	15/ 1588	7/ 9	6/ 91
16.	IIT (BHU), Varanasi [IIT(BHU)] ( <a href="http://www.iitbhu.ac.in">www.iitbhu.ac.in</a> )	1916 (2012)	INI (IIT)	Public	16/ 1432	0	29/ 1
17.	PSG College of Technology (PSG), Coimbatore ( <a href="http://www.psgtech.edu/">http://www.psgtech.edu/</a> )	1951	AIC	Public	17/ 1381	11/ 2	10/ 26
18.	NIT Karnataka, Surathkal (NIT-K) ( <a href="http://www.nitk.ac.in">www.nitk.ac.in</a> )	2002 (1960)*	INI (NIT)	Public	18/ 1377	0	0
19.	NIT, Durgapur, WB (NIT-DGP) ( <a href="http://www.nitdgp.ac.in">www.nitdgp.ac.in</a> )	2003 (1960)*	INI (NIT)	Public	19/ 1281	0	29/ 1
20.	Vellore Institute of Technology (VIT), Vellore ( <a href="http://www.vit.ac.in/">http://www.vit.ac.in/</a> )	1984	UNI (DU)	Private	20/ 988	10/ 3	7/ 51



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21.	NIT, Warangal, AP (NIT-W) ( <a href="http://www.nitw.ac.in">www.nitw.ac.in</a> )	2002 (1959)*	INI (NIT)	Public	21/ 980	0	28/ 2
22.	Motilal Nehru National Institute of Technology (MNNIT), Allahabad ( <a href="http://www.mnnit.ac.in">www.mnnit.ac.in</a> )	2007 (1961)*	INI (NIT)	Public	22/ 937	0	23/ 7
23.	NIT, Calicut (NIT-C) ( <a href="http://www.nitc.ac.in">www.nitc.ac.in</a> )	2002 (1961)*	INI (NIT)	Public	23/ 908	11/ 2	18/ 12
24.	IIT, Indore (IIT-I) ( <a href="http://www.iiti.ac.in">www.iiti.ac.in</a> )	2009	INI (IIT)	Public	24/ 902	0	20/ 10
25.	Thiagarajar College of Engineering (TCE), Madurai ( <a href="https://www.tce.edu/">https://www.tce.edu/</a> )	1987	AIC	Public	25/ 882	8/ 5	19/ 11
26.	NIT, Kurukshetra, Haryana (NIT-KKR)( <a href="http://www.nitkk.ac.in">www.nitkk.ac.in</a> )	2008 (1963)*	INI (NIT)	Public	26/ 834	0	28/ 2
27.	Manipal Institute of Technology (MIT), Manipal ( <a href="https://manipal.edu/mit.html">https://manipal.edu/mit.html</a> )	1957	AIC	Private	27/ 812	5/ 13	9/ 43
28.	NIT, Hamirpur, HP (NIT-HMR)( <a href="http://www.nith.ac.in">www.nith.ac.in</a> )	2002 (1986)*	INI (NIT)	Public	28/ 697	0	29/ 1
29.	IIT, Bhubaneswar (IIT-BBS)( <a href="http://www.iitbbs.ac.in">www.iitbbs.ac.in</a> )	2009	INI (IIT)	Public	29/ 694	0	22/ 8
30.	Jaypee Institute of Information Technology (JIIT), Noida ( <a href="http://www.jiit.ac.in/">http://www.jiit.ac.in/</a> )	2001	UNI (DU)	Private	30/ 689	0	29/ 1
31.	Visvesvaraya National Institute of Technology (VNIT), Nagpur ( <a href="http://www.vnit.ac.in">www.vnit.ac.in</a> )	2002 (1960)*	INI (NIT)	Public	31/ 685	12/ 1	27/ 3
32.	College of Engineering (COE), Pune ( <a href="http://www.coep.org.in">http://www.coep.org.in</a> )	1854	AIC	Public	32/ 671	0	18/ 12
33.	IIT, Ropar (IIT-RPR) ( <a href="http://www.iitrpr.ac.in">www.iitrpr.ac.in</a> )	2009	INI (IIT)	Public	33/ 627	0	28/ 2
34.	NIT, Tiruchirapalli (NIT-T) ( <a href="http://www.nitt.edu">www.nitt.edu</a> )	2003 (1964)*	INI (NIT)	Public	34/ 620	0	24/ 6
35.	IIT, Patna (IIT-P) ( <a href="http://www.iitp.ac.in">www.iitp.ac.in</a> )	2009	INI (IIT)	Public	35/ 597	0	24/ 6
36.	Indian Institute of Engineering Science and Technology (IEST), Shibpur ( <a href="http://www.iests.ac.in/">http://www.iests.ac.in/</a> )	1856	INI (IEST)	Public	36/ 565	0	25/ 5
37.	Bannari Amman Institute of Technology (BAIT), Sathyamangalam ( <a href="http://www.bitsathy.ac.in/">http://www.bitsathy.ac.in/</a> )	1996	AIC	Private	37/ 546	0	0
38.	National Institute of Engineering (NIE), Mysuru ( <a href="http://www.nie.ac.in/">www.nie.ac.in/</a> )	1946	AIC	Private	38/ 537	0	20/ 10
39.	Dr. B.R. Ambedkar NIT, Jalandhar, Punjab (NIT-J) ( <a href="http://www.nitj.ac.in">www.nitj.ac.in</a> )	2002 (1987)*	INI (NIT)	Public	39/ 532	0	27/ 3
40.	Kongu Engineering College (KEN), Coimbatore ( <a href="http://www.kct.ac.in/">http://www.kct.ac.in/</a> )	1984	AIC	n.a.	40/ 501	0	26/ 4
41.	Sona College of Technology (SCT), Salem ( <a href="http://www.sonatech.ac.in/">http://www.sonatech.ac.in/</a> )	1997	AIC	Private	41/ 470	11/ 2	16/ 17



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42.	IIT, Mandi (IIT-MN) ( <a href="http://www.iitmandi.ac.in">www.iitmandi.ac.in</a> )	2009	INI (IIT)	Public	42/ 468	0	0
43.	NIT, Agartala, Tripura (NIT-AG) ( <a href="http://www.nita.ac.in">www.nita.ac.in</a> )	2006 (1965)*	INI (NIT)	Public	43/ 465	0	28/ 2
44.	IIT, Gandhi Nagar (IIT-GN) ( <a href="http://www.iitgn.ac.in">www.iitgn.ac.in</a> )	2009	INI (IIT)	Public	44/ 460	0	26/ 4
45.	NIT, Silchar, Assam (NIT-S) ( <a href="http://www.nits.ac.in">www.nits.ac.in</a> )	2002 (1967)*	INI (NIT)	Public	45/ 458	0	0
46.	Kumaraguru College of Technology (KGCT), Coimbatore ( <a href="http://www.kct.ac.in/">http://www.kct.ac.in/</a> )	1984	AIC	Private	46/ 446	0	0
47.	B.S. Abdur Rahman Institute of Science and Technology (BSARHST), Vandalu ( <a href="http://www.bsauiv.ac.in/">http://www.bsauiv.ac.in/</a> )	1984	UNI (D-T-B)	Private	47/ 430	0	29/ 1
48.	NIT, Raipur, Chhattisgarh (NIT-RR)( <a href="http://www.nitr.ac.in">www.nitr.ac.in</a> )	2005 (1956)*	INI (NIT)	Public	48/ 400	0	0
49.	Sri Ramakrishna Engineering College (SREC), Coimbatore ( <a href="http://www.srec.ac.in/">http://www.srec.ac.in/</a> )	1994	AIC	Private	49/ 368	0	0
50.	Pondicherry Engineering College (PEC), Pondicherry ( <a href="http://www.pec.edu/">www.pec.edu/</a> )	1984	AIC	Public	50/ 362	12/ 1	21/ 9
51.	Noida Institute of Engineering & Technology (NIET), Noida ( <a href="http://www.niet.co.in/">http://www.niet.co.in/</a> )	2001	AIC	Private	51/ 360	0	0
52.	Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat ( <a href="http://www.svnit.ac.in">www.svnit.ac.in</a> )	2003 (1961)*	INI (NIT)	Public	52/ 304	0	19/ 11
53.	<i>Indian Institutes of Science Education and Research (IISER), Mohali (<a href="http://www.iisermohali.ac.in">www.iisermohali.ac.in</a>)</i>	2007	INI (IISER)	Public	53/ 268	0	18/ 12
54.	Sant Longowal Institute of Engineering & Technology (SLIET), Sangrur ( <a href="http://sliet.ac.in/">sliet.ac.in/</a> )	1989	UNI (DU)	Public	54/ 261	12/ 1	0
55.	M. S. Ramaiah Institute of Technology (MSRIT), Bangalore ( <a href="http://www.msrit.edu/">www.msrit.edu/</a> )	1962	AIC	Private	55/ 256	12/ 1	25/ 5
56.	Punjab Engineering College (PEC), Chandigarh ( <a href="http://www.pec.ac.in/">www.pec.ac.in/</a> )	1921	UNI (DU)	Public	56/ 256	0	28/ 2
57.	Adhiyamaan College of Engineering (ACE), Hosur ( <a href="http://www.adhiyamaan.ac.in/">http://www.adhiyamaan.ac.in/</a> )	1987	AIC	Private	57/ 242	0	0
58.	IIT, Jodhpur (IIT-J) ( <a href="http://www.iitj.ac.in">www.iitj.ac.in</a> )	2009	INI (IIT)	Public	58/ 232	0	27/ 3
59.	NIT, Srinagar, J&K (NIT-Sri) ( <a href="http://www.nitsri.net">www.nitsri.net</a> )	2003 (1960)*	INI (NIT)	Public	59/ 226	0	0
60.	NIT, Jamshedpur, Jharkhand (NIT-JSR) ( <a href="http://www.nitjsr.ac.in">www.nitjsr.ac.in</a> )	2002 (1960)*	INI (NIT)	Public	60/ 200	0	0
61.	Institute of Engineering & Management (IEM), Kolkata ( <a href="http://www.iem.edu.in/">http://www.iem.edu.in/</a> )	1989	AIC	Private	61/ 189	0	20/ 10



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62.	Siddaganga Institute of Technology (SIT), Tumkur (www.sit.ac.in/)	1963	AIC	Private	62/ 188	0	8/ 46
63.	College of Technology & Engineering (CTE), Udaipur (http://www.ctae.ac.in/)	1964	AIC	Public	63/ 163	0	0
64.	NIT, Delhi (NIT-D) (www.nitdelhi.ac.in)	2010	INI (NIT)	Public	64/ 162	0	0
65.	Bengal Institute of Technology (BIT), Kolkata (http://www.bitcollege.in/)	2000	AIC	Private	65/ 155	0	0
66.	National Institute of Science & Technology (NIST), Berhampur (http://www.nist.edu/)	1996	AIC	Private	66/ 153	0	0
67.	University Institute of Chemical Engineering & Technology (UICET), Panjab University, Chandigarh	1958	Uni Deptt.	Public	67/ 152	0	0
68.	Hindustan Institute of Technology & Science (HITS), Agra (https://www.hindustanuniv.ac.in/)	1985	UNI (D-T-B)	Private	68/ 142	0	14/ 22
69.	Vishwakarma Institute of Technology (VIT), Pune (www.vit.edu/)	1983	AIC	Private	69/ 134	0	27/ 3
70.	Institute of Technology (IoT), Nirma University, Ahmedabad (www.nirmauni.ac.in/ITNU)	1995	AIC	Private	70/ 132	0	23/ 7
71.	NIT, Patna, Bihar (NIT-P) (www.nitp.ac.in)	2004 (1886)*	INI (NIT)	Public	71/ 126	0	0
72.	C.V. Raman College of Engineering (CVRCOE), Bhubaneswar (cvrce.edu.in/)	1997	AIC	Private	72/ 120	0	0
73.	School of Engineering & Technology (SET), Itm University, Gwalior(http://www.itmuniversity.ac.in/)	1997	Uni Deptt.	Private	73/ 102	0	27/ 3
74.	NIT, Meghalaya, Sholong (NIT-ML) (www.nitm.ac.in)	2010	INI (NIT)	Public	74/ 97	0	0
75.	University Institute of Chemical Technology (UICT), North Maharashtra University, Jalgaon (nmu.ac.in/udct/)	1994	UNI (SU)	Public	75/ 94	9/ 4	15/ 21
76.	<i>Indian Institute of Information Technology, Design and Manufacturing (IIITDM), Kancheepuram (www.iiitdm.ac.in/)</i>	2005	INI (IITDM)	Public	76/ 87	0	0
77.	Chaitanya Bharathi Institute of Technology (CBIT), Hyderabad (http://www.cbit.ac.in/)	1979	AIC	Private	77/ 75	0	28/ 2
78.	Government College of Engineering (GOE), Aurangabad (http://geca.ac.in/)	1960	AIC	Public	78/ 72	0	29/ 1
79.	Anand Institute of Higher Technology (AIHT), Chennai (www.aiht.ac.in/)	2000	AIC	Private	79/ 63	0	0
80.	Centurion Institute of Technology (CIT), Jatni	2005	UNI (SU)	Private	80/ 62	0	0



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	( <a href="https://www.cutm.ac.in/">https://www.cutm.ac.in/</a> )						
81.	Veermata Jijabai Technological Institute (VJTI), Mumbai ( <a href="http://www.vjti.ac.in/">http://www.vjti.ac.in/</a> )	1887	AIC	Public	81/ 62	0	0
82.	Bharati Vidyapeeth, Pune ( <a href="http://www.bharativedyapeeth.edu/">bharativedyapeeth.edu/</a> )	1964	UNI (DU)	Public	82/ 60	0	10/ 26
83.	Koneru Lakshmaiah Education Foundation (KLEF), Vaddeswara ( <a href="http://www.klef.ac.in/">http://www.klef.ac.in/</a> )	1980	UNI (D-T-B)	n.a.	83/ 53	0	0
84.	Shanmugha Arts Science Technology & Research Academy (SASTRA), Thirumalaisamudram ( <a href="http://www.sastra.edu/">http://www.sastra.edu/</a> )	1984	UNI (DU)	Private	84/ 52	12/ 1	12/ 24
85.	Kalinga Institute of Industrial Technology (KIIT), Bhubaneswar ( <a href="http://kiit.ac.in/">http://kiit.ac.in/</a> )	1992	UNI (D-T-B)	Private	85/ 45	0	0
86.	Malaviya National Institute of Technology (MNIT), Jaipur, Rajasthan ( <a href="http://www.mnit.ac.in/">www.mnit.ac.in</a> )	2002 (1963)*	INI (NIT)	Public	86/ 45	0	18/ 12
87.	Noorul Islam Centre for Higher Education, (NICHE), Kanyakumari ( <a href="http://www.niuniv.com/">http://www.niuniv.com/</a> )	1989	UNI (D-T-B)	Private	87/ 45	0	0
88.	Yeshwantrao Chavan College of Engineering (YCCOE), Nagpur ( <a href="http://www.ycce.edu/">http://www.ycce.edu/</a> )	1984	AIC	Private	88/ 41	0	29/ 1
89.	Shri Guru Gobind Singhji Institute of Engineering & Technology (SGGSIET), Nanded ( <a href="https://www.sggs.ac.in/">https://www.sggs.ac.in/</a> )	1981	AIC	Public	89/ 38	0	25/ 5
90.	Shri Ramdeobaba College of Engineering & Management (SRCEM), Ramdeo Tekdi, Gittikhadan, Katol Road, Nagpur-Nagpur ( <a href="http://www.rknec.edu/">http://www.rknec.edu/</a> )	1984	AIC	Private	90/ 33	11/ 2	24/ 6
91.	IIITDM, Jabalpur ( <a href="http://www.iiitdmj.ac.in/">http://www.iiitdmj.ac.in/</a> )	2007	INI (IITDM)	Public	91/ 30	0	0
92.	NIT, Goa (NIT-GA) ( <a href="http://www.nitgoa.ac.in/">www.nitgoa.ac.in</a> )	2010	INI (NIT)	Public	92/ 29	0	0
93.	Vignan's Foundation for Science, Technology & Research (VFSTR), Guntu ( <a href="http://www.vignanuniversity.org/">http://www.vignanuniversity.org/</a> )	2008	UNI (DU)	Private	93/ 26	0	0
94.	Maharashtra Academy of Engineering & Educational Research (MAEER), Pune ( <a href="http://www.mitaoe.ac.in/">http://www.mitaoe.ac.in/</a> )	1999	AIC	Public	94/ 24	0	0
95.	K. K. Wagh Institute of Engineering Education & Research (KKWIEER), Nashik ( <a href="http://www.kkwagheducosoc.org/kkwagh/">http://www.kkwagheducosoc.org/kkwagh/</a> )	1984	AIC	Private	95/ 23	0	17/ 15
96.	Kasegaon Education Societys (KES), Rajarambapu Institute of Technology-Islampur ( <a href="http://www.kongu.edu/">www.kongu.edu/</a> )	1983	AIC	Private	96/ 23	0	0



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97.	R.V. College of Engineering (RVCE), Bengaluru (www.rvce.edu.in/)	1963	AIC	Private	97/ 18	0	0
98.	Karunya Institute of Technology & Sciences (KITS), Coimbatore (http://karunya.edu/)	1986	UNI (D-T-B)	Private	98/ 18	0	22/ 8
99.	**Amrita School of Engineering (ASE), ASS, Ettimadai(https://www.amrita.edu/school/engineering)	1994	Uni Deptt.	Private	99/ 13	0/ 0	0/ 0
100.	Sagi Ramakrishnam Raju Engineering College (SRREC), Bhimavaram (www.srkrec.ac.in/)	1980	AIC	Private	100/ 1	0	0

n.a.- not available; \*- These NITs were established during the period (1886-1987) as Regional Engineering Colleges; later on they were upgraded to NITs in the year mentioned in braces; \*\*-Patents filed and granted from ASE (Engineering department under AVV, Ettimadai) are included in patents published and granted on name of AVV, Ettimadai.

IIT: Indian Institute of Technology; DU: Deemed University, D-T-B: Deemed to be University; SU: State University; CU: Central University, AIC: Autonomous Institute or College; NIT: National Institute of Technology; IISER: Indian Institute of Science Education and Research; IIITDM: Indian Institute of Information Technology, Design and Management; IEST: Indian Institutes of Engineering Science and Technology.

**Table 2: Fields categorization for patents & research articles publications**

S. No.	Extracted Fields for Patents from Various Patents Search Tools		Extracted Fields for Research Articles from Scopus
1.	Engineering	<ul style="list-style-type: none"> <li>• Mechanical Engineering</li> <li>• Electronics and Communication Engineering</li> <li>• Electrical Engineering</li> </ul>	<ul style="list-style-type: none"> <li>• Engineering</li> <li>• Computer Science</li> </ul>
2.	Chemical Sciences		<ul style="list-style-type: none"> <li>• Chemistry</li> <li>• Chemical Engineering</li> <li>• Material Science</li> </ul>
3.	Physics		Physics & Astronomy
4.	Biotech/Food/Agri.	<ul style="list-style-type: none"> <li>• Biotechnology/ Biological Science</li> <li>• Food/Agriculture</li> </ul>	<ul style="list-style-type: none"> <li>• Agricultural and Biological Sciences</li> <li>• Biochemistry and Genetics and Molecular Biology</li> <li>• Immunology &amp; Microbiology</li> <li>• Environmental Sciences</li> </ul>
5.	Pharma/Drug		Pharmacology, Toxicology and Pharmaceutics
6.	Medical Science		<ul style="list-style-type: none"> <li>• Medicine</li> <li>• Health Profession</li> <li>• Dentistry</li> <li>Neuroscience</li> </ul>



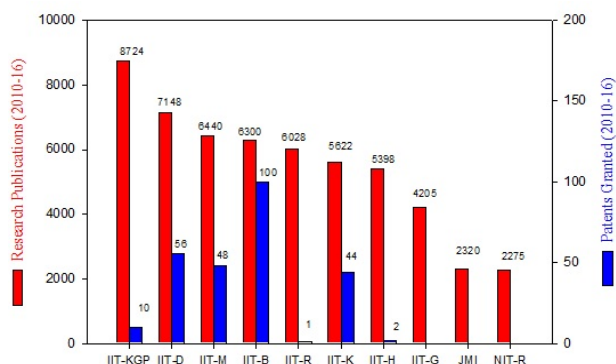


Fig. 2 Top 10 Engineering Institutes based on Research Publications (2010-16)

Note: Abbreviations as mentioned in table 1

range of research publications varied between 150-500 (~300 publications annually), which is highly satisfactory.

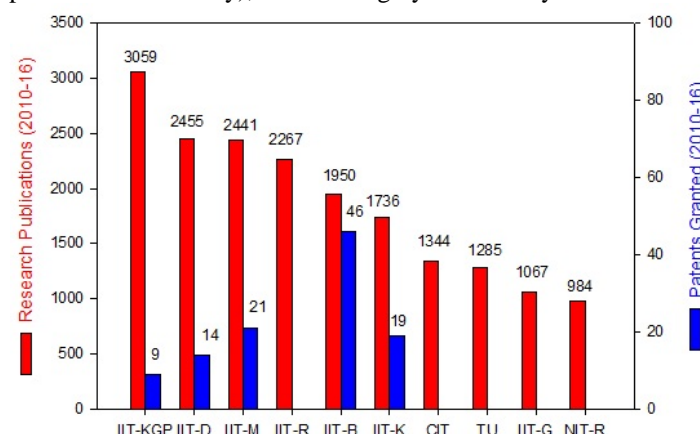


Fig. 4 Top 10 Engineering Institutes based on Research Publications in Engineering

Note: Abbreviations as mentioned in table 1

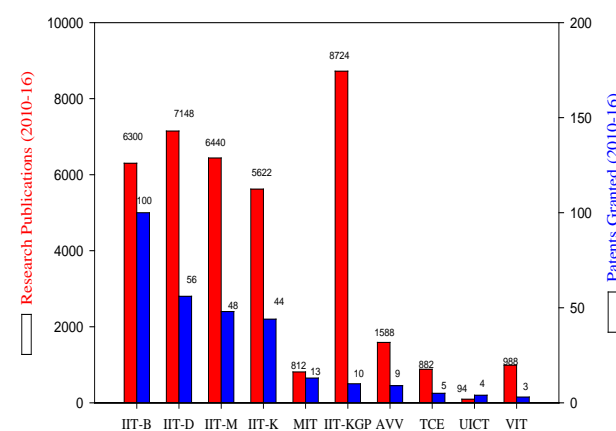


Fig. 3 Top 10 Engineering Institutes based on Patents (Granted; 2010-16)

Note: Abbreviations as mentioned in table 1

Based on patent (granted) ranking, top 10 engineering institutes were dominated by IITs (6). Four of them had double digit score, lead by IIT-B (46) and followed by IIT-M (21), IIT-K (19), and IIT-D (14). The number of patents (granted) to other two IITs (IIT-KGP and IIT-H) was 9 and 2 respectively (Fig.5). The non IIT institutes figuring in the top rankings for patent (granted) category, were MIT, Manipal (rank 5, patents-11); TCE, Madurai (rank 7, patents-5), VIT-Vellore (rank 8, patents-3) and AVV, Ettimadai (rank 9, patents-2).

➤ Subject Field Wise Analysis

The engineering institutes cater not only to Engineering branches such as Mechanical, Electrical, Civil, Computer Science etc., but also have made a mark in other fields like Chemical Sciences, Physics, Biotech/Food/Agriculture, Medical Sciences and Pharma sector (Table 2).

As already mentioned the sources of data extraction for research articles and patents were different, and the subject classification criterion of both the sources was diverse. The best possible way for fields' combination was taken up to justify the comparison of both the parameters [research articles & patents (granted)]. Eventually, the main motive of the research is to find out those universities which are lagging behind in converting their research outcome into patents/technologies. The fields' combination is mentioned below in Table 2. The results of the top ten ranked institutes in each field are discussed below.

a.) Engineering

Seven out of 10 top rankings were dominated by IITs [IIT-KGP: 3059; IIT-D: 2455; IIT-M: 2441; IIT-R: 2267; IIT-B: 1950 and IIT, Ghandinagar (IIT-G): 1067] in the domain of research publications (Fig.4). The other 3 institutes were Coimbatore Institute of Technology (CIT), Coimbatore (rank: 7; research publications: 1344) followed by Thapar University (TU), Patiala (rank: 8; research publications: 1285) and NIT-R (rank: 10; research publications: 984). On annual basis the

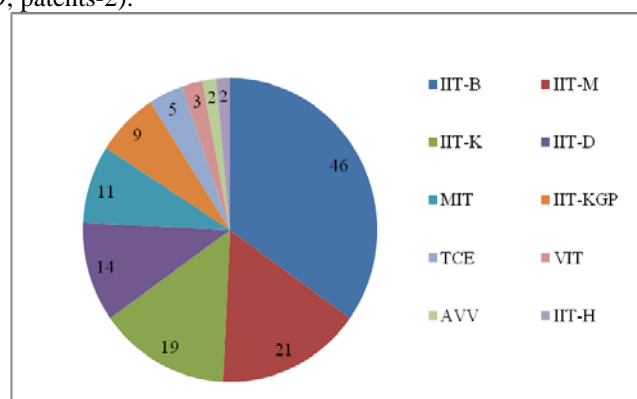


Fig. 5 Top 10 Engineering Institutes based on Patents (Granted) in Engineering

Note: Abbreviations as mentioned in table 1

b.) Chemical Sciences

Like the field of Engineering, IITs dominated in the field of Chemical Sciences, on the basis of research publications. Out of top 10 rankings, 8 positions were held by IITs (IIT-KGP: 3759; IIT-M: 3218; IIT-D: 3017; IIT-K: 2934; IIT-B: 2648; IIT-R: 2196 and IIT-H: 1600). The remaining two rankings were held by TU, Patiala (1326 publications) and JMI, New Delhi (1260 publications) (Fig.6).

On analysing these top 10 institutes on scale of patents (granted), it was observed that IITs mainly IIT-B (29); IIT-M (22), IIT-D (17) and IIT-K (17) were also active in number of patents (granted). Surprisingly, IIT-KGP which published maximum number of research publications in the field of Chemical Sciences had no patent (granted) to its credit.



Similarly, IIT-G and IIT-H who have published the good number of research publications in the field of Chemical Sciences had no patent (granted). Whereas, universities like TU, Patiala and JMI, New Delhi performed well in research in the field of Chemical Sciences as documented through more than 1000 research publications in the same field but have not been able to draw any patent (granted) to its name in spite of being the premier engineering institutes of India.

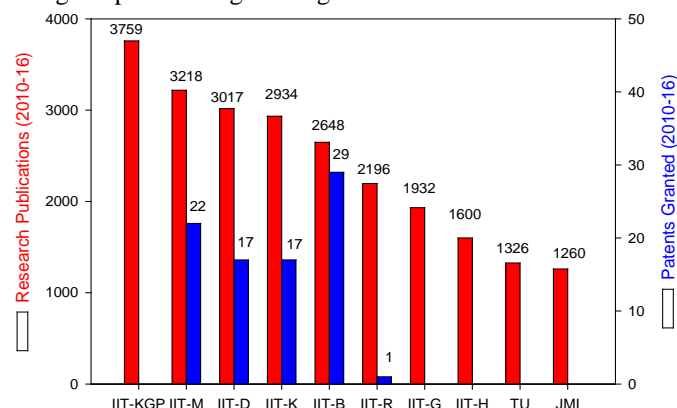


Fig. 6 Top 10 Engineering Institutes based on Research Publications in Chemical Sciences

Note: Abbreviations as mentioned in table 1

On basis of patents (granted) in the field of Chemical Sciences, top 4 institutes were IITs (IIT-B: 29; IIT-M: 22; IIT-D: 17 and IIT-K: 17) followed by University Institute of Chemical Technology (UICET), Jalgaon (3); VIT, Vellore (2); NIT, Calicut (NIT-C; 2); Shri Ramdeobaba College of Engineering and Management (SRCEM), Nagpur (2); MIT, Manipal (1) and PSG College of Technology (PSG), Coimbatore (1) (Fig.7). IITs and NIT-C are INI and rest of the four institutes are private universities.

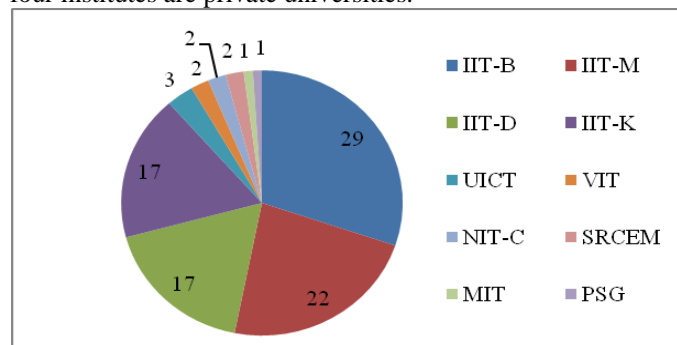


Fig. 7 Top 10 Engineering Institutes based on Patents (Granted) in Chemical Sciences

Note: Abbreviations as mentioned in table 1

c.) Physics

The field of Physics is an active subject in engineering institutes as evidenced by the number of research publications. Top ten ranked institutes published >70 research articles per year. Top ranked institute was second generation IIT i.e. IIT-H with research publications 1596 (Fig.8). Interestingly, this IIT had a better record of publications than other 6 first generation IITs (IIT-KGP: 751; IIT-D: 694; IIT-B: 615; IIT-M: 566 and IIT-K: 439) ranked among top 10 institutes. The other three institutes active in the field of Physics were TU, Patiala (rank: 3; research publications: 700); JMI, New Delhi (rank: 6; research publications: 575) and Cochin University of Science

and Technology (CUST), Cochin (rank: 9; research publications: 480). On analysing the patents (granted) data for the above mentioned top 10 institutes it was observed that these institutes have no patents granted to their credit except first generation IITs which had patents (granted) in the range of 1-9.

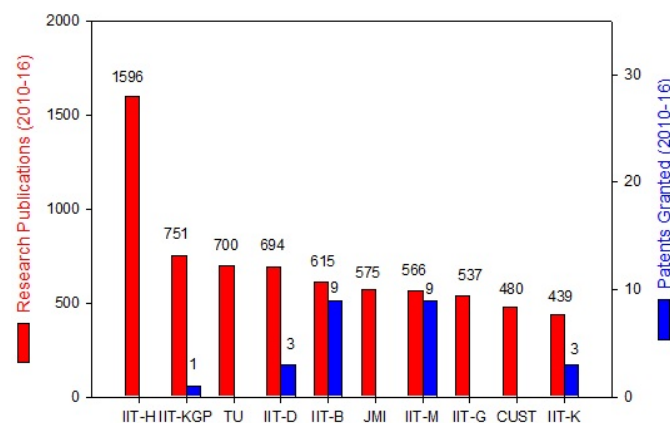


Fig. 8 Top 10 Engineering Institutes based on Research Publications in Physics

Note: Abbreviations as mentioned in table 1

The patents (granted) data in the field of Physics revealed that none of the top 100 NIRF engineering institute had an impressive record in this category. None of the institute held ten or more patents (granted) (Fig.9). IIT-B and IIT-M held 9 patents (granted) during the period of study (2010-16). Non IIT institutes such as AVV, Ettimadai held 3 patents on its name followed by NIT-C, Kerala and TCE, Madurai with 2 patents. IIT-D, IIT-K and IIT-KGP have 3, 3 and 1 patents (granted), respectively.

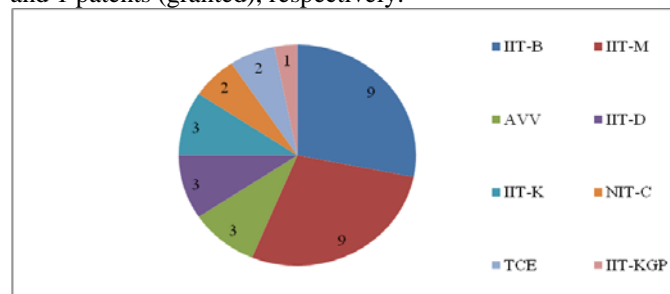


Fig. 9 Top Engineering Institutes based on Patents (Granted) in Physics

Note: Abbreviations as mentioned in table 1

d.) Biotech/Food/Agriculture

This domain of Biological Sciences was introduced in the engineering institutes somewhere at end of 20<sup>th</sup> century. It has grown rapidly, in IITs, as evidenced by the number of research publications coming out from these institutes. The data mentioned in the Fig.10, showed that among the top 10 institutes publishing research articles in the field of biotech and its related domains, 9 institutes were IITs. The top leading institute was IIT-H with 6452 research publications. The other IITs amongst top 10 institutes in terms of research publication in Biotech and associated field were first generation IITs (IIT-KGP: 4705; IIT-M: 3324; IIT-B: 3235; IIT-D:3045; IIT-K: 2932 IIT-R: 2751) and second generation IITs namely IIT-G (2678) and IIT, Bhubaneswar (IIT-BHU; 869). The lone non-IIT amongst the top rankings was NIT-R occupying 9<sup>th</sup> ranking. The data analysis, on the basis of patents (granted),



revealed that none of the institutes considered for this study has much to show in the patent (granted) category. Only 24 patents were granted. Nine belonged to IIT-B, 5 each to IIT-M and IIT-D, 4 to IIT-K and 1 to CUST (Fig.11). IIT-H and IIT-KGP, leaders in research publications in the field of Biotech/Food/Agri. had no patent (granted) to their credit.

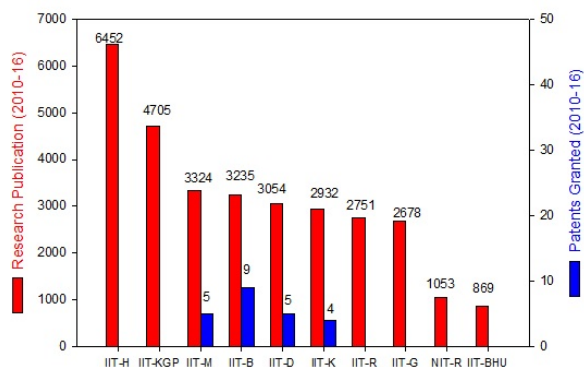


Fig. 10 Top 10 Engineering Institutes based on Research Publications in Biotech/Food/Agri.

Note: Abbreviations as mentioned in table 1

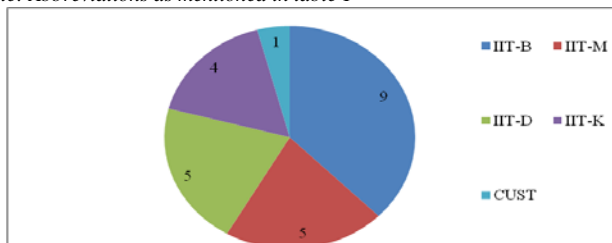


Fig. 11 Top Engineering Institutes based on Patents (Granted) in Biotech/Food/Agri.

Note: Abbreviations as mentioned in table 1

e.) Pharma/Drugs

Engineering concepts have been widely applied in the field of Pharmaceuticals, Drug Formulations and Drug Designing. Therefore, in this study top engineering institutes in terms of research publications and patents (granted) in the field of Pharma/Drug were analysed (Figures 12 and 13). On basis of research publications, out of top 10 institutes, 6 IITs namely IIT-KGP (rank: 1; research publications: 579), IIT-B (rank: 2; research publications: 545); IIT-R (rank: 3; research publications: 505); IIT-D (rank: 4; research publications: 364); IIT-K (rank: 6; research publications: 268) and IIT-M (rank: 7; research publications: 268) have reasonable standings. The other institutes among the top 10 rankings were Birla Institute of Technology (BIT), Ranchi (rank-5<sup>th</sup>); JMI, New Delhi (rank-8<sup>th</sup>); AVV, Ettimadai (rank-9<sup>th</sup>) and NIT, Karnataka (NIT-K; rank-10<sup>th</sup>). Out of these top 10 institutes, institutes such as IIT-B (14); AVV, Ettimadai (5); IIT-M (4); IIT-K (1) and IIT-D (1) held patents (granted) to their credit, rest of the institutes have not opened their account in patent (granted).

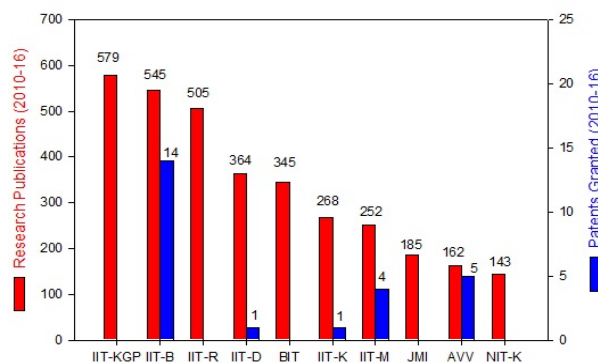


Fig. 12 Top 10 Engineering Institutes based on Research Publications in Pharma/Drug

Note: Abbreviations as mentioned in table 1

Similarly, on analysing top performing institutes in terms of patent (granted) in the field of Pharma/Drug, IIT-B was found to have maximum number of granted patent (14) followed by AVV, Ettimadai (5), IIT-M (4), IIT-D (1) and IIT-K (1) (Fig.13). No other engineering institute held any patent (granted) in the field of pharma and drug in their name.

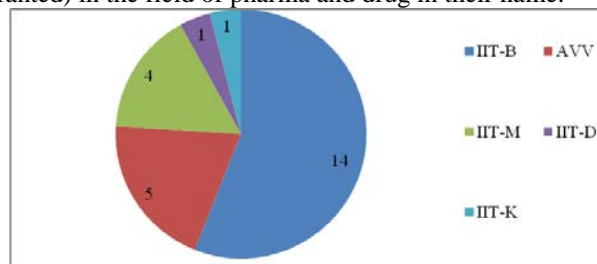


Fig. 13 Top Engineering Institutes based on Patents (Granted) in Pharma/Drug

Note: Abbreviations as mentioned in table 1

f.) Medical Sciences

Medical Science is a vast field comprising of specializations in the field of Medicines, Medical Devices, Dentistry etc. The devices and diagnostics in this field have engineering as an important component. Therefore, engineering institutes are also imparting education in the domain of Medical Sciences. The top 10 ranking institutions comprised of 7 IITs (IIT-KGP: 924; IIT-K: 771; IIT-M: 721; IIT-D: 652; IIT-R: 651; IIT-B: 601 and IIT-G: 370) and three other institutes namely JMI, New Delhi, NIT-R and AVV, Ettimadai with research publications ranging from 150-450 (Fig.14). Unfortunately, patents (granted) regime of engineering institutes in the domain of Medical Sciences (3 to IIT-B and one each to IIT-D, IIT-K, AVV and TCE) was quite disappointing (Fig.15).

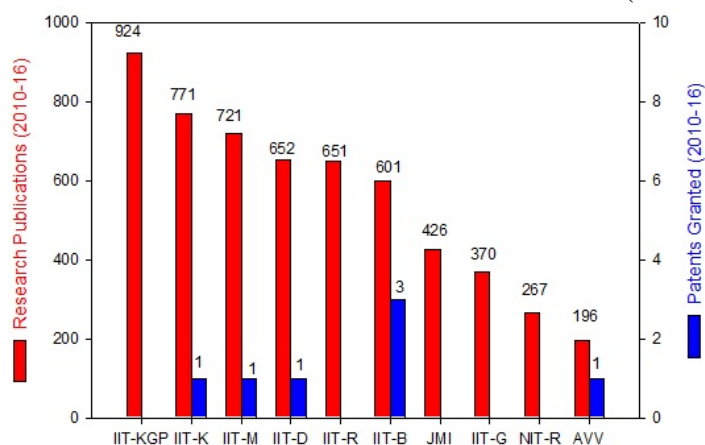


Fig. 14 Top 10 Engineering Institutes based on Research Publications in Medical Sciences

Note: Abbreviations as mentioned in table 1

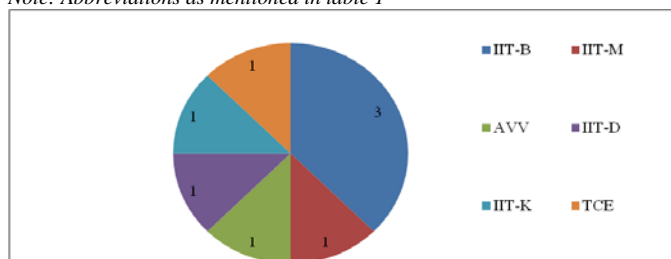


Fig. 15 Top Engineering Institutes based on Patents (Granted) in Medical Sciences

Note: Abbreviations as mentioned in table 1

#### IV. DISCUSSION & CONCLUSIONS

The economic prosperity of a nation has been linked with its science innovation ecosystem, which in turn is dependent on the research publications and the patent regime of HEIs. The field of engineering is one of the important pillars of higher education and contributes greatly to the technological advancements of the nations, worldwide [11]. Keeping this in mind, a study was undertaken to evaluate the top 100 NIRF ranked engineering institutes of India, out of a total lot of more than 3000 engineering institutes [12] on R&D parameters of research publications and patenting profile for the period 2010 to 2016.

In India, the engineering institutes can be categorized into INIs, AICs and universities. Though all the classes were represented in the top 100 NIRF engineering institutes, but top 10 rankings were largely secured by first generation IITs, in the domains of research publications as well as patents (granted). These IITs are the flag bearers of engineering education in India and have global recognition as well. The major attributes that have led IITs to be at the forefront of engineering are a) globally competitive academic faculty, excellent infrastructure and research facilities including centres of excellence set up in conjunction with industries, b) autonomy in their governance, teaching and research programmes, c) substantial funds (from the government) for research activities, d) existence of 'Translation Research Ecosystem' (TRE) comprising of industry-academia cell, IPR cell, technology transfer cell, entrepreneurship cells and technology business incubators, and e) participation of industry in governing, academic teaching, curriculum

designing and training, thus imparting full exposure to the students to pursue engineering work especially R&D activities as per industry needs [13]. The revenue generated through patent licensing by first-generation IITs till 2015 was: ₹186.80 crores by IIT-KGP, ₹209 crores by IIT -B, ₹461crores by IIT-M, ₹135.83 crores by IIT-D [13]. The data presented in the current study indicated that the patents (granted) and research publications of second and third generation IITs were much less than first generation IITs. It is on the expected lines, as newly established IITs are laying more emphases on hiring faculty, strengthening academic curricula, constructing buildings for class-room teaching, research laboratories and hostels.

Like IITs, NITs, earlier known as Regional Engineering College, were established from 1959 onwards to meet the growing demand of technology-based industries for highly trained engineering graduates and postgraduates whom IITs alone could not provide [14]. Although 22 NITs figure in the top 100 NIRF engineering institutes, but the research publications and patents (granted) profile of majority of NITs is far from satisfactory. Only 9 NITs published >100 research articles every year during 2010-16. Compared to 221 patents (granted) of IITs, only 3 patents were granted to NITs located in Calicut (2) and Hamirpur (1).

Amongst top 100 NIRF engineering institutes, maximum number of institutes belonged to AICs (35) followed by universities (23), NITs (22) and IITs (16). Despite, AICs having maximum number of institutes in top 100 NIRF ranking, none of the institutes figured in top 10 rankings based on research publications. Only two institutes, CIT, Coimbatore (13) and PSG College of Technology, Coimbatore (17), found a place in the top 20 rankings for number of research publications. The situation was more or less similar for patents (granted) as only six AICs have a total of 12 patents (granted) during 2010-16.

The patent (granted) and publication profile of universities is only a shade better than AICs. JMI, New Delhi is the only university finding a spot (rank 9) in the top ten ranked NIRF engineering institutes on research publication parameter. Five universities (private-3; public-2) held a total of 15 granted patents. The patents and publications of only two universities (AVV, Ettimadai and VIT-Vellore) had acceptable levels of publications and patents (granted).

The data presented in this study clearly suggests that only a handful of engineering institutions, primarily first generation IITs, have satisfactory levels of publications and patents (granted). Nearly, one third of the top 100 NIRF engineering institutes published good number of research articles, but were found wanting in generating patents (granted). The patent regime of these institutions can be enhanced by identifying the gaps in its IPR regime e.g. lack of awareness about IPRs, absence of IPR Cell or existence of non-functional IPR Cell and so on. By understanding the patent (granted) and publication ecosystem of IITs, these institutes can certainly boost their fundamental and translational research. As MHRD is emphasizing on promoting 'Translation Research' in universities, it is suggested that it should provide dedicated funds for the



establishment of 'Patent Cells' and 'Technology Transfer Cells' in the universities having good reputation of publishing research papers. In addition, MHRD may introduce a scheme for 'Incentivizing Institutes/Scientists' engaged in generating patents as is prevalent in countries like USA [15] and China [16].

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