Contribution and Citation Impact of Eight New IITs: A Scientometric Assessment of their Publications during 2010-14

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ABSTRACT

This paper analyzes 3656 research publications of the eight new Indian Institutes of Technology (IITs) as covered in Scopus International database covering the period 2010-14 with the purpose to understand their comparative performance in research. The findings reveal that publications of eight new IITs increased at an annual average rate of 68.78% and registered an average citation impact per paper of 4.63. About 35.39% and 28.34% publications of eight new IITs resulted from national and international collaboration respectively during 2010-14. The major areas of research across eight new IITs were engineering, physics & astronomy, computer science, materials science and chemistry, constituting institutional publication share of 34.85%, 27.05%, 25.16%, 22.16% and 18.90% in their total output during 2010-14. Mathematics, chemical engineering, energy, biochemistry, genetics & molecular biology, social sciences and medicine constituted as the 6 medium productive subject areas of new IITs with institutional share of 11.41%, 9.05%, 6.35%, 6.18%, 5.44% and 4.68% during 2010-14. Thirty five (35) significant authors across eight new IITs together accounted for 41.68% share in the total output of IITs during 2010-14. About 26 high cited papers were published by these eight new IITs, which received 50 and above citations per paper in five years. Amongst these 26 papers, 17 received 50 to 99 citations and 9 other 100-226 citations per paper.Twenty six highly cited papers (17 papers in citation range 50-99 and 9 papers in citation range 100 to 276) together received 2392 citations, registering an average citation per paper of 92.0.

INTRODUCTION

The Indian Institutes of Technology (IITs) are branded as world class autonomous institutes and comes under the Ministry of Human Resources Development (MHRD), Government of India. IITs are established as per the Institutes of Technology Act of India, 1961 and they have declared as "institutions of national importance". The

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existing 16 IITs are located at Chennai, Delhi, Guwahati, Kanpur, Kharagpur, Mumbai, Roorkee, Bhubaneswar, Gandhinagar, Hyderabad, Indore, Jodhpur, Mandi, Patna, Ropar and Varanasi. Out of 16 IITs, 8 IITs are newly started. In addition to B.Tech, M.Tech and MS programs, IITs also offering degrees in M.Sc. in Physics, Chemistry and Mathematics, MBA, PhD etc. The Ministry of Human Resources Development, Government of India, to expand and enhance the quality of technical education in India, started the eight new IITs: IIT Bhubaneswar, IIT Gandhinagar, IIT Hyderabad, IIT Patna, IIT Jodhpur, and IIT Ropar in 2008 and IIT Indore and IIT Mandi in 2009. All the new IITs are offering undergraduate, post-graduate and research degree programmes in varieties of disciplines. These new institutions are at various stages of expansion and they have given utmost importance for the development of research infrastructure. One of the main objectives of IITs is to reach global standards in research, mostly in engineering and technology. At the same time good research is happening in the certain areas of basic sciences and humanities. Though the new IITs

have started 6-7 years back, their research output is very promising.

Literature Review

There are only few papers analyzing the performance of IITs and other such group of institutions in the past. Prathap[1] benchmarked the recent research performance of the IITs in academic research in the area of engineering science and technology in the country against that of similarly placed institutions in the world using bibliometric indicators from the Web of Science and Scopus data-bases. Solanki, Uddin and Singh[2] measured the research competitiveness of Indian Institutes of Science Education and Research (IISERs) through a scientometric analysis of their research output during the last five years (2010–14). The research output indexed in Web of Science of the five recently established IISERs has been obtained and analysed computationally to identify growth trends, per capita output, authorship and collaboration patterns, citation impact, average citation per paper, etc. The research performance of IISERs is also compared with the Indian Institute of Science and the Indian Institute of Technology system to obtain an assessment of their research potential. Bala and Kumari[3] study analysed the research performance of National Institutes of Technology (NITs) of India during 2001-2010 on several parameters including NITs overall contribution, its growth pattern, citation impact, the share of international collaboration, identification of significant participating countries in NITs international collaboration, contribution and impact by different subject areas, identification of weak and strong subject areas, productivity and impact of prolific authors, pattern of communication of NITs output in most productive journals and characteristics of high cited papers of NITs. Prathap and Gupta[4] presented a ranking of research performance of 67 Indian engineering and technological institutes using data from Scopus international bibliographical database, using a recently introduced *p*-index, which can serve as a composite indicator that combines quality with quantity.

Objectives of the Study

The main objectives of the present study are to analyze the broad characteristic features of the publications output of eight New IITs during 2010-14, using quantitative and qualitative indicators. In particular the study focuses on the following aspects: (i) To study the growth and citation impact of its research output; (ii) To study the research output and citation impact under and narrow broad subject areas; (iii) To analyse its national and international collaboration; (iv) To study the media of communication and characterstics of its high cited papers.

Methodology

Using affliation search, Indian Institute of Technology was searched and it resulted in listing of all 16 IITs. Each new IIT was selected one by one and its search was restricted to years 2010-14 under "year tag". Using this search strategy string (shown below), the publication data was further analysed using the tags of "authorship", "subject area", "document type", "source type", "source title", "keywords", "affiliation" and "country/territory" for information on collaborative countries and publications, source journals, most productive authors, etc. Similar exercise was undertaken for all the eight new IITs. In the last the publication data of all eight new IITs was combined. For impact factor, SJR data has been used. A number of quantitative and qualitative indicators have been used here to study the performance of IITs.

AF-ID ("Indian Institute of Technology Hyderabad" 60103917) OR AF-ID ("Indian Institute of Technology Indore" 60104350) OR AF-ID ("Indian Institute of Technology Patna" 60104342) OR AF-ID ("Indian Institute of Technology Bhubaneswar" 60104339) OR AF-ID ("Indian Institute of Technology Ropar" 60103918) OR AF-ID ("Indian Institute of Technology Gandhinagar" 60104341) OR AF-ID ("Indian Institute of Technology Mandi" 60104340) OR AF-ID ("Indian Institute of Technology Rajasthan" 60104343)

Analysis

The eight new IITs together contributed 3656 publications during 2010-14, increasing from 184 in 2010 to 1408 in 2014, registering an annual average growth rate of 68.78%. The highest number of publications (823) was contributed by IIT-Hyderabad during 2010-14, followed by IIT-Indore (577), IIT-Patna (562), IIT-Bhubaneshwar (531), IIT-Ropar (445), IIT-Gandhinagar (307), IIT-Mandi (238) and IIT-Jodhpur (173) during 2010-14. In terms of individual new IITs, the highest annual average publication growth rate (348.10%) was registered by IIT-Mandi, followed by IIT-Indore (138.53%), followed by IIT-Jodhpur (90.56%), IIT-Ropar (86.51%), IIT-Hyderabad (61.55%), IIT-Gandhinagar (58.45%), IIT-Patna (58.18%) and IIT-Bhubaneswar (51.11%) during 2010-14. The citation impact per paper registered by all publications of eight new IITs varied from 2.65 of IIT-Jodhpur to 6.72 of IIT-Ropar, with an average citation impact of 4.63 during 2010-14 (Table 2-3). In terms of share of

cited (1 or more times) papers in total output of eight new IITs, IIT-Ropar registered the highest share (73.26%), followed by IIT-Indore (68.28%), IIT-Bhubaneswar (65.35%), IIT-Hyderabad (60.02%), IIT-Mandi (59.66), IIT-Gandhinagar (54.07%), IIT-Patna (53.38%) and IIT-Jodhpur (50.87%) during 2010-14.

National Collaborative Publications

The national collaborative output of 8 new IITs consists of 1301 publications (Table 4-5), which constituted 35.59% share of its total output during 2010-14. The share of national collaborative output of individual eight new IITshowever varied from 24.96% (IIT-Indore) to 52.02% (IIT-Jodhpur) during 2010-14.

International Collaboration

The number of international collaborative publications of eight new IITs consisted of 1036 publications (Table 6-7), which constituted 28.34% share of its total output during 2010-14. The individual share of international collaborative publications of eight new IITs varied from 14.06% to 41.60% during 2010-14. The international collaborative linkages of new IITs with different countries are shown in Table 8.

Subject-Wise Distribution of Publications

The broad subject-wise distribution of output of 8 New IITs are shown in Table 9. The subject-wise output is discussed under: (i) major productive subject areas; (ii) medium productive subject areas and (i) least productive subject areas.

Most Productive Subject Areas

Engineering, physics & astronomy, computer science, materials science and Chemistry are the five most productive subject areas of new IITs, with publication share of 34.85%, 27.05%, 25.16%, 22.16% and18.90% to the total output of new IITs during 2010-14. Chemistry registered the highest citation per paper (8.30) among these five subject areas, followed by physics & astronomy (6.11), materials science (5.35), engineering (3.49) and computer science (1.92) during 2010-14.

In engineering, IIT-Hyderabad contributed the largest number of papers with institutional publication share of 37.91%, followed by IIT-Bhub (42.94%), IIT-Patna (34.70%), IIT-Indore (29.64%), IIT-Ropar (36.85%), IIT-Gandhi (26.38%), IIT-Jodhpur (42.77%) and IIT-Mandi (21.01%) during 2010-14. IIT-Ropar and IIT-Gandhi registered the highest citation impact per paper of 4.49 and 4.57, followed by IIT-Bhub (3.86), IIT-Mandi (3.74), IIT-Hyderabad (3.48), IIT-Indore (3.06), IIT-Patna (2.91) and IIT-Jodhpur (1.22) during 2010-14 (Table 10).

In physics & astronomy, IIT-Indore contributed the largest number of papers (195) with institutional publication share of 33.80%, followed by IIT-Hyderabad (22.24%), IIT-Bhub (30.70%), IIT-Ropar (33.93%), IIT-Patna (18.68%), IIT-Mandi (35.29%), IIT-Gandhi (20.52%) and IIT-Jodhpur (20.52%) during 2010-14. IIT-Indore registered the highest citation impact per paper of 10.10, followed by IIT-Patna (8.52), IIT-Ropar (6.42), IIT-Gandhi (5.52), IIT-Bhub (5.01), IIT-Hyderabad (4.08), IIT-Jodhpur (3.35) and IIT-Mandi (2.81) during 2010-14 (Table 11).

In computer science, IIT-Hyderabad and contributed the largest number of papers with institutional publication share of 27.70% and 36.65%, followed by IIT-Indore (26.17%), IIT-Bhub (20.34%), IIT-Gandhi (20.85%), IIT-Mandi (24.37%), IIT-Jodhpur (31.79%) and IIT-Ropar (11.91%) during 2010-14. IIT-Ropar registered the highest citation impact per paper of 3.21, followed by IIT-Bhub (3.09), IIT-Indore (2.15), IIT-Patna (1.80), IIT-Jodhpur (1.53), IIT-Hyderabad (1.39), IIT-Gandhi (1.36) and IIT-Mandi (1.33) during 2010-14 (Table12).

In materials science, IIT-Hyderabad, IIT-Ropar and IIT-Patna contributed the largest number of papers with institutional publication share of 21.75%, 33.71% and 23.49%, followed by IIT-Bhub (22.60%), IIT-Indore (18.20%), IIT-Mandi (25.21%), IIT-Gandhi (11.73%) and IIT-Jodhpur (17.92%) during 2010-14. IIT-Patna registered the highest citation impact per paper of 7.43, followed by IIT-Ropar (5.54), IIT-Hyderabad (5.29), IIT-Bhub(5.0), IIT-Jodhpur (4.68), IIT-Mandi (4.48), IIT-Gandhi (4.17) and IIT-Indore (3.97) during 2010-14 (Table 13).

In Chemistry, IIT-Hyderabad, IIT-Indore and IIT-Ropar contributed the largest number of papers with institutional publication share of 21.99%, 24.61% and 27.64%, followed by IIT-Patna (15.30%), IIT-Bhub(10.92%), IIT-Mandi (23.95%) and IIT-Jodhpur (5.20%) during 2010-14. IIT-Jodhpur, IIT-Bhub and IIT-Patna registered the highest citation impact per paper of 12.33, 10.48 and 10.31, followed by IIT-Ropar (9.93), IIT-Indore (8.49), IIT-Hyderabad (6.88), IIT-Mandi (5.26) and IIT-Gandhi (4.50) during 2010-14 (Table 14).

Table 1: Growth of Publications of Eight New IITs during 2010-14

Publication Year	Number of Publications of New IITs								
	Hyde	Indore	Patna	Bhuban	Ropar	Gandhinagar	Mandi	Jodhpur	Total
2010	48	10	36	37	17	27	2	7	184
2011	98	34	82	69	47	24	26	23	403
2012	151	99	94	97	103	36	35	49	664
2013	215	180	156	142	113	85	63	39	993
2014	313	254	194	186	159	135	112	55	1408
Total	823	577	562	531	445	307	238	173	3656

Table 2: Citation Output of Eight New IITs during 2010-14

Publication Year	Number of Citations of New IITs								
	Hyde	Indore	Patna	Bhuban	Ropar	Gandhinagar	Mandi	Jodhpur	Total
2010	273	165	212	430	229	116	7	9	1441
2011	527	145	720	601	516	204	112	204	3029
2012	834	1046	438	596	933	176	143	120	4286
2013	760	1666	464	665	821	380	276	93	5125
2014	600	774	311	324	493	233	264	33	3032
Total	2994	3796	2145	2616	2992	1109	802	459	16913

Table 3: Average Citations per Paper of Eight New IITs during 2010-14

Publication Year	Average Citations Per Paper of New IITs								
	Hyde	Indore	Patna	Bhuban	Ropar	Gandhinagar	Mandi	Jodhpur	Total
2010	5.69	16.50	5.89	11.62	13.47	4.30	3.50	1.29	7.83
2011	5.38	4.26	8.78	8.71	10.98	8.50	4.31	8.87	7.52
2012	5.52	10.57	4.66	6.14	9.06	4.89	4.09	2.45	6.45
2013	3.53	9.26	2.97	4.68	7.27	4.47	4.38	2.38	5.16
2014	1.92	3.05	1.60	1.74	3.10	1.73	2.36	0.60	2.15
Total	3.64	6.58	3.82	4.93	6.72	3.61	3.37	2.65	4.63

Table 4: Number of National Collaborative Publications of Eight New IITs during 2010-14

Publication Year	Number of National Collaborative Publications								
	Hyde	Indore	Patna	Bhuban	Ropar	Gandhinagar	Mandi	Jodhpur	Total
2010	24	1	27	24	7	17	1	5	106
2011	48	7	39	46	20	5	11	18	194
2012	58	25	39	48	44	10	16	28	268
2013	75	47	50	42	38	20	11	15	298
2014	90	64	51	76	61	43	26	24	435
Total	295	144	206	236	170	95	65	90	1301

Table 5: Share of National Collaborative Publications of Eight New IITs during 2010-14

Publication Year	Share of National Collaborative Publications								
	Hyde	Indore	Patna	Bhuban	Ropar	Gandhinagar	Mandi	Jodhpur	Total
2010	50.0	10.0	75.0	64.86	41.18	62.96	50.00	71.43	57.61
2011	48.98	20.59	47.56	66.67	42.55	20.83	42.31	78.26	48.14
2012	38.41	25.25	41.49	49.48	42.72	27.78	45.71	57.14	40.36
2013	34.88	26.11	32.05	29.58	33.63	23.53	17.46	38.46	30.01
2014	28.75	25.20	26.29	40.86	38.36	31.85	23.21	43.64	30.89
Total	35.84	24.96	36.65	44.44	38.20	30.94	27.31	52.02	35.59

Table 6: Number of International Collaborative Publicationsof Eight New IITs during 2010-14

Publication Year	No. of International Collaborative Publications								
	Hyde	Indore	Patna	Bhuban	Ropar	Gandhinagar	Mandi	Jodhpur	Total
2010	18	2	6	9	9	5	0	0	49
2011	39	11	14	15	13	13	12	6	123
2012	48	41	17	19	32	16	15	10	198
2013	59	63	17	48	42	37	34	12	312
2014	65	66	25	50	42	55	38	13	354
Total	229	183	79	141	138	126	99	41	1036

Table 7: Share of International Collaborative Publications of Eight New IITs during 2010-14

Publication Year	Share. of International Collaborative Publications								
	Hyde	Indore	Patna	Bhuban	Ropar	Gandhinagar	Mandi	Jodhpur	Total
2010	37.50	20.00	16.67	24.32	52.94	18.52	0.00	0.00	26.63
2011	39.80	32.35	17.07	21.74	27.66	54.17	46.15	26.09	30.52
2012	31.79	41.41	18.09	19.59	31.07	44.44	42.86	20.41	29.82
2013	27.44	35.00	10.90	33.80	37.17	43.53	53.97	30.77	31.42
2014	20.77	25.98	12.89	26.88	26.42	40.74	33.93	23.64	25.14
Total	27.83	31.72	14.06	26.55	31.01	41.04	41.60	23.70	28.34

Table 8: International Collaborative Linkages of New IITs with different countries, 2010-14

Collaborative Country	Number of International Collaborative Publications								
	Hyd	Indore	Patna	Bhub	Ropar	Gandhi	Mandi	Jodhpur	Total
USA	65	86	29	53	48	82	49	13	422
Germany	39	93	6	18	9	28	4	10	207
U.K.	39	79	1	25	22	29	12	0	206
Japan	34	86	5	9	4	14	3	1	161
South Korea	4	74	3	7	23	19	1	6	132
China	9	77	2	12	3	15	5	1	124
France	13	68	0	4	6	17	5	2	115
Italy	12	68	7	5	0	19	3	0	114
Poland	5	77	0	6	0	14	0	0	102
Russia Federation	0	81	0	5	0	15	0	1	102
Sweden	4	90	0	2	0	0	3	0	99
Spain	3	64	2	5	1	16	0	1	97
Netherlands	2	64	0	3	3	15	1	1	89
Switzerland	4	68	0	9	0	3	0	0	86
Brazil	0	63	2	3	1	15	2	0	86
Total	295	183	79	141	138	126	99	41	1034

Medium Productive Subject Areas

Mathematics, chemical engineering, energy, biochemistry, genetics & molecular biology, social sciences and medicine are the 6 medium productive subject areas with institutional share of 11.41%, 9.05%, 6.35%, 6.18%, 5.44% and 4.68% during 2010-14. Biochemistry, genetics & molecular biology registered the highest citation per paper (8.42) among these six subject areas, followed by chemical engineering (6.82), medicine (6.01), energy (5.20), mathematics (2.83) and social sciences (1.34) during 2010-14.

In mathematics, IIT-Patna and IIT-Hyderabad contributed the largest number of papers with institutional

Table 9: Broad Subject-Wise Distribution of 8 New IITs Output during 2010-14

Broad Subject	Eight New IITs						
	TP	%TP	TC	ACPP	HI	ICP	%ICP
Engineering	1274	34.85	4440	3.49	24	308	24.18
Physics &Astronomy	989	27.05	6045	6.11	33	326	32.96
Computer Science	920	25.16	1763	1.92	19	185	20.11
Materials Science	810	22.16	4330	5.35	24	225	27.78
Chemistry	691	18.90	5738	8.30	28	187	27.06
Mathematics	417	11.41	1179	2.83	13	112	26.86
Chemical Engineering	331	9.05	2257	6.82	20	85	25.68
Energy	232	6.35	1206	5.20	17	49	21.12
Biochemistry, Genetics & Molecular Biology	226	6.18	1902	8.42	21	76	33.63
Social Sciences	199	5.44	266	1.34	9	44	22.11
Medicine	171	4.68	1028	6.01	15	71	41.52
Environment Science	114	3.12	799	7.01	14	38	33.33
Earth & Planetary Science	103	2.82	289	2.81	9	53	51.46
Pharmacology, Toxicology & Pharmaceutics	79	2.16	990	12.53	18	29	36.71
Arts & Humanities	48	1.31	83	1.73	5	11	22.92
Agricultural & Biological Sciences	34	0.93	144	4.24	7	12	35.29
Neurosciences	23	0.63	143	6.22	7	12	52.17
Total of all IITs	3656			0.00	283	1823	

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; HCP=High Cited papers (receiving 100 or more citations); NCP=National Collaborative Publications and ICP=International Collaborative Publications'

Table 10: Scientometric Profile of Engineering Research in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	312	1085	3.48	18	98	31.41	37.91
IIT-Indore	171	523	3.06	10	38	22.22	29.64
IIT-Patna	195	567	2.91	13	22	11.28	34.7
IIT-Bhubaneswar	228	879	3.86	15	47	20.61	42.94
IIT-Ropar	164	753	4.59	14	40	24.39	36.85
IIT-Gandhinagar	81	370	4.57	8	30	37.04	26.38
IIT-Mandi	50	187	3.74	7	18	36.00	21.01
IIT-Jodhpur	74	90	1.22	6	14	18.92	42.77

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 11: Scientometric Profile of Physics Research in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	183	746	4.08	13	63	34.43	22.24
IIT-Indore	195	1970	10.10	26	112	57.44	33.80
IIT-Patna	105	895	8.52	15	11	10.48	18.68
IIT-Bhubaneswar	163	817	5.01	13	49	30.06	30.70
IIT-Ropar	151	969	6.42	16	43	28.48	33.93
IIT-Gandhinagar	63	348	5.52	10	34	53.97	20.52
IIT-Mandi	84	236	2.81	7	2	2.38	35.29
IIT-Jodhpur	49	164	3.35	7	12	24.49	28.32

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 12: Scientometric Profile of Computer Science Research in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	228	316	1.39	9	49	21.49	27.70
IIT-Indore	151	324	2.15	9	20	13.25	26.17
IIT-Patna	206	371	1.80	9	26	12.62	36.65
IIT-Bhubaneswar	108	334	3.09	10	25	23.15	20.34
IIT-Ropar	53	170	3.21	7	13	24.53	11.91
IIT-Gandhinagar	64	87	1.36	5	27	42.19	20.85
IIT-Mandi	58	77	1.33	4	15	25.86	24.37
IIT-Jodhpur	55	84	1.53	6	10	18.18	31.79

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 13: Scientometric Profile of Materials Science Research in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	179	947	5.29	24	25	13.97	21.75
IIT-Indore	105	417	3.97	10	35	33.33	18.2
IIT-Patna	132	981	7.43	14	15	11.36	23.49
IIT-Bhubaneswar	120	600	5.00	12	27	22.50	22.6
IIT-Ropar	150	831	5.54	15	38	25.33	33.71
IIT-Gandhinagar	36	150	4.17	4	10	27.78	11.73
IIT-Mandi	60	269	4.48	8	25	41.67	25.21
IIT-Jodhpur	31	145	4.68	5	9	29.03	17.92

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 14: Scientometric Profile of Chemistry Research in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	181	1246	6.88	17	42	23.20	21.99
IIT-Indore	142	1206	8.49	18	30	21.13	24.61
IIT-Patna	86	887	10.31	13	12	13.95	15.3
IIT-Bhubaneswar	58	608	10.48	14	13	22.41	10.92
IIT-Ropar	123	1222	9.93	19	45	36.59	27.64
IIT-Gandhinagar	36	162	4.50	6	16	44.44	11.73
IIT-Mandi	57	300	5.26	8	23	40.35	23.95
IIT-Jodhpur	9	111	12.33	3	6	66.67	5.2

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 15: Scientometric Profile of Mathematics Research in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	83	197	2.37	7	23	27.71	10.09
IIT-Indore	51	106	2.08	5	12	23.53	8.84
IIT-Patna	90	214	2.38	8	19	21.11	16.01
IIT-Bhubaneswar	47	215	4.57	6	10	21.28	8.85
IIT-Ropar	39	198	5.08	7	7	17.95	8.76
IIT-Gandhinagar	37	58	1.57	4	15	40.54	12.05
IIT-Mandi	43	130	3.02	7	21	48.84	18.07
IIT-Jodhpur	27	61	2.26	4	5	18.52	15.61

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

publication share of 16.01% and 10.09%, followed by IIT-Indore (8.84%), IIT-Bhub (8.85%), IIT-Mandi (18.07%), IIT-Ropar (8.76%), IIT-Gandhi (12.05%) and IIT-Jodhpur (15.61%) during 2010-15. IIT-Ropar registered the highest citation impact per paper of 5.08, followed by IIT-Bhub (4.57), IIT-Mandi (3.02), IIT-Patna (2.38), IIT-Hyderabad (2.37), IIT-Indore (2.08) and IIT-Gandhi (1.57) during 2010-14 (Table 15).

In chemical engineering, IIT-Ropar and IIT-Hyderabad contributed the largest number of papers with institutional publication share of 16.85% and 8.87%, followed by IIT-Indore (9.71%), IIT-Patna (7.83%), IIT-Gandhi (11.40%), IIT-Bhub (5.84%), IIT-Mandi (4.44%) during 2010-14 . IIT-Ropar registered the highest citation impact per paper (9.15), followed by IIT-Indore (8.77), IIT-Bhub (7.48), IIT-Hyderabad (5.63), IIT-Patna (4.48), IIT-Gandhi (3.77) and IIT-Mandi (3.07) during 2010-14 (Table 16).

In energy subject field, IIT-Hyderabad and IIT-Bhub contributed the largest number of papers with institutional publication share of 7.53% and 10.17%, followed by IIT-Patna (5.87%), IIT-Ropar and IIT-Indore (5.39% each), IIT-Gandhi (5.86%), IIT-Mandi (3.78%) and IIT-Jodhpur (4.62%) during 2010-14 . IIT-Gandi registered the highest citation impact per paper (10.17), followed by IIT-Indore (6.42), IIT-HYderabad (5.71), IIT-Jodhpur (5.63), IIT-Bhub (4.83), IIT-Ropar (4.54), IIT-Mandi (2.67) and IIT-Patna (2.30) during 2010-14(Table 17).

In the area of biochemistry, genetics & molecular biology, IIT-Hyderabad, IIT-Ropar and IIT-Indore contributed the largest number of papers with institutional publication share of 5.95%, 10.34% and 7.80%, followed by IIT-Bhub (6.03%), IIT-Patna (3.20%), IIT-Gandhi (4.56%), IIT-Mandi (5.46%) and IIT-Jodhpur (5.20%) during 2010-14. IIT-Ropar and IIT-Bhub registered the highest citation impact per paper (13.41 and 10.66), followed by IIT-Patna (9.22), IIT-Indore (7.93), IIT-Hyderabad (5.43), IIT-Mandi (4.92), IIT-Gandhi (4.57) and IIT-Mandi (3.00) during 2010-14 (Table 18).

In the area of social sciences, IIT-Hyderabad, IIT-Patna and IIT-Bhubaneshwar contributed the largest number of papers with institutional publication share of 6.20%, 7.47% and 5.27%, followed by IIT-Mandi (10.5%), IIT-Gandhinagar (7.17%), IIT-Indore (2.60%), IIT-Ropar (3.15%) and IIT-Jodhpur (2.31%) during 2010-14. IIT-Bhubaneswar and IIT-Patna registered the highest citation impact per paper (2.14 and 1.71), followed by IIT-Mandi (1.68), IIT-Indore (1.27), IIT-Hyderabad

(0.71), IIT-Gandhinagar (0.59) and IIT-Jodhpur (0.25) during 2010-14 (Table 19).

In the area of medicine, IIT-Hyderabad , IIT-Indore and IIT-Ropar contributed the largest number of papers with institutional publication share of 4.25%, 5.55% and 5.84%, followed by IIT-Gandhinagar (7.82%), IIT-Patna and IIT-Bhubaneswar (2.31% and 2.45%). IIT-Mandi (7.14%) and IIT-Jodhpur (6.36%) during 2010-14. IIT-Bhbaneswar registered the highest citation impact per paper (16.23), followed by IIT-Indore (7.41), IIT-Ropar (7.27), IIT-Gandhinagar (6.38), IIT-Jodhpur (4.27), IIT-Patna (2.31) and IIT-Hyderabad (2.31) during 2010-14 (Table 20).

Least Productive Subject Areas

Environment science, earth & planetary sciences, pharmacology, toxicology, agricultural & biological sciences and neurosciences are the 5 least productive subject areas with institutional share of 3.12%, 2.82%, 2.16, 0.93% and 0.63% during 2010-14. Pharmacology, toxicology and pharmaceutical science registered the highest citation per paper (12.53) among these five subject areas, followed by environment science (7.01), neurosciences (6.22), agricultural & biological sciences (4.24) and earth & planetary sciences (2.81) during 2010-14.

In environment science, IIT-Hyderabad and IIT-Bhubaneswar contributed the largest number of papers with institutional publication share of 3.65% and 5.08%, followed by IIT-Patna (2.49%), IIT-Ropar (2.92%), IIT-Gandhinar (4.23%), IIT-Jodhpur (7.51%), IIT-Mandi (3.36% share) and IIT-Indore (1.04% share) during 2010-14. IIT-Indore registered the highest citation impact per paper of 15.17, followed by IIT-Bhubaneswar (9.37), IIT-Hyderabad (7.43), IIT-Gandhinar and IIT-Jodhpur (6.23), IIT-Ropar (4.38), IIT-Patna (4.36) and IIT-Mand (3.0) during 2010-14 (Table 21).

In earth & planetary science, IIT-Bhubaneswar and IIT-Hyderabad contributed the largest number of papers with institutional publication share of 7.91%, 10.10% and 2.92%, followed by IIT-Ropar (1.12%) and IIT-Indore (0.17) during 2010-14. IIT-Gandhinagar registered the highest citation impact per paper of 4.13, followed by IIT-Ropar (3.0), IIT-Hyderabad (2.42) and IIT-Indore (2.0) during 2010-14 (Table 22).

High Productivity Authors

The productivity of top 35 most productive authors, from across 8 new IITs, varied from 21 to 82 papers

Table 16: Scientometric Profile of Chemical Engineering Research in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	73	411	5.63	12	16	21.92	8.87
IIT-Indore	56	491	8.77	11	12	21.43	9.71
IIT-Patna	44	197	4.48	8	3	6.82	7.83
IIT-Bhubaneswar	31	232	7.48	5	9	29.03	5.84
IIT-Ropar	75	686	9.15	14	23	30.67	16.85
IIT-Gandhinagar	35	132	3.77	5	14	40.00	11.40
IIT-Mandi	15	46	3.07	4	6	40.00	4.44
IIT-Jodhpur							

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 17: Scientometric Profile of Energy Research in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	62	354	5.71	11	8	12.90	7.53
IIT-Indore	24	154	6.42	7	8	33.33	4.16
IIT-Patna	33	76	2.30	6	5	15.15	5.87
IIT-Bhubaneswar	54	261	4.83	9	11	20.37	10.17
IIT-Ropar	24	109	4.54	7	7	29.17	5.39
IIT-Gandhinagar	18	183	10.17	4	3	16.67	5.86
IIT-Mandi	9	24	2.67	3	6	66.67	3.78
IIT-Jodhpur	8	45	5.63	1	1	12.50	4.62

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 18: Scientometric Profile of Biochemistry, Genetics & Molecular Biology in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	49	266	5.43	9	11	22.45	5.95
IIT-Indore	45	357	7.93	10	10	22.22	7.80
IIT-Patna	18	166	9.22	7	4	22.22	3.20
IIT-Bhubaneswar	32	341	10.66	10	8	25.00	6.03
IIT-Ropar	46	617	13.41	16	26	56.52	10.34
IIT-Gandhinagar	14	64	4.57	5	7	50.00	4.56
IIT-Mandi	13	64	4.92	4	7	53.85	5.46
IIT-Jodhpur	9	27	3.00	3	3	33.33	5.20

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

per author and together they contributed 1524 papers, cumulated 18321 citations, and accounted for 41.68% share of 8 IITs total papers during 2010-14. A scientometric profile of the top 35 authors of new IITs is presented in Table 23. Amongst these 35 authors, 13 were in physics,7 in chemistey, 6 in electrical engineering, 3 in computer science, 2 each in chemical engineering and mathematics and 1 each in engineering and mechanical engineering. Of these 35 authors, 13 are affiliated to IIT-Indore, 10 to IIT-Hyderabad, 8 to IIT-Patna, 3 to IIT-Bhubaneswar and 1 to IIT-Ropar. The average productivity per author was 43.54 and 14 authors have contributed more than average productivity of all authors: N.Singh (82 papers), S.M. Mobin (79 papers), R.Verma (76 papers), B.K.Nandi (73 papers), R.Sahoo (69 papers), A.N.Mishra, D.P.Mahaptra and T.K.Nayak (65 papers

Table 19: Scientometric Profile of Social Sciences in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	51	36	0.71	3	11	21.57	6.20
IIT-Indore	15	19	1.27	2	0	0.00	2.60
IIT-Patna	42	72	1.71	5	4	9.52	7.47
IIT-Bhubaneswar	28	60	2.14	3	7	25.00	5.27
IIT-Ropar	14	23	1.64	2	4	28.57	3.15
IIT-Gandhinagar	22	13	0.59	3	10	45.45	7.17
IIT-Mandi	25	42	1.68	4	8	32.00	10.50
IIT-Jodhpur	4	1	0.25	1	0	0.00	2.31

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 20: Scientometric Profile of Medicine in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	35	81	2.31	5.00	14.00	40.00	4.25
IIT-Indore	32	237	7.41	9	12	37.50	5.55
IIT-Patna	13	43	3.31	3	2	15.38	2.31
IIT-Bhubaneswar	13	211	16.23	5	4	30.77	2.45
IIT-Ropar	26	189	7.27	8	12	46.15	5.84
IIT-Gandhinagar	24	153	6.38	7	16	66.67	7.82
IIT-Mandi	17	67	3.94	6	7	41.18	7.14
IIT-Jodhpur	11	47	4.27	4	4	36.36	6.36

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 21: Scientometric Profile of Environment Science in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	30	223	7.43	8	6	20	3.65
IIT-Indore	6	91	15.17	4	2	33.33	1.04
IIT-Patna	14	61	4.36	4	1	7.14	2.49
IIT-Bhubaneswar	27	253	9.37	4	10	37.04	5.08
IIT-Ropar	13	57	4.38	5	7	53.85	2.92
IIT-Gandhinagar	13	81	6.23	4	3	23.08	4.23
IIT-Mandi	8	24	3.00	2	7	87.50	3.36
IIT-Jodhpur	13	81	6.23	4	2	15.38	7.51

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

Table 22: Scientometric Profile of Earth & Planetary Sciences in New IITs during 2010-14

Name of IIT	TP	TC	ACPP	HI	ICP	%ICP	Institutional Share
IIT-Hyd	24	58	2.42	4	14	58.33	2.92
IIT-Indore	1	2	2.00	1	0	0.00	0.17
IIT-Patna	-	-	-	-	-	-	-
IIT-Bhubaneswar	42	87	2.07	5	25	59.52	7.91
IIT-Ropar	5	15	3.00	2	1	20.00	1.12
IIT-Gandhinagar	31	128	4.13	7	13	41.94	10.10
IIT-Mandi	-	-	-	-	-	-	-
IIT-Jodhpur	-	-	-	-	-	-	-

TP=Total Papers; TC=Total Citations; ACPP=Average Citations Per Paper; HI-h-index; ICP=International Collaborative Publications

S.No	Name of Author	Affiliation	Subject	TP	TC	ACPP	HI	ICP	%ICP
	Table 23: Scientometric Profile of 35 Most Productive Authors of 8 new IITs during 2010-14								
1	N.Singh	IIT-Ropar	Chem	82	762	9.29	16	38	46.34
2	S.M.Mobin	IIT-Indore	Chem	79	624	7.90	14	14	17.72
3	R.Verma	IIT-Indore	Physics	76	1589	20.91	25	76	100.00
4	B.K.Nandi	IIT-Indore	Physics	73	1558	21.34	25	72	98.63
5	R.Sahoo	IIT-Indore	Physics	69	1421	20.59	23	66	95.65
6	A.N.Mishra	IIT-Indore	Physics	65	1262	19.42	23	63	96.92
7	D.P.Mahaptra	IIT-Indore	Physics	65	1417	21.80	23	64	98.46
8	T.K.Nayak	IIT-Indore	Physics	65	1416	21.78	23	65	100.00
9	A.Gupta	IIT-Indore	Physics	64	1416	22.13	23	64	100.00
10	R.Raniwalah	IIT-Indore	Physics	64	1416	22.13	23	64	100.00
11	P.K.Sahoo	IIT-Indore	Physics	64	1416	22.13	23	23	35.94
12	U.B.Desai	IIT-Hyderabad	Electric	52	76	1.46	4	7	13.46
13	A.Bowmick	IIT-Patna	Rubber Tech	47	625	13.30	11	9	19.15
14	S.N.Merchant	IIT-Hyderabad	Electric	44	63	1.43	4	7	15.91
15	G. Saantaray	IIT-Bhubaneswar	Electrical	43	207	4.81	7	9	20.93
16	N.S.Chaudhari	IIT-Indore	Computer	40	28	0.70	2	2	5.00
17	C.Subrahmanyam	IIT-Hyderabad	Chemistry	38	316	8.32	11	7	18.42
18	S.Saha	IIT-Patna	Computer	37	112	3.03	6	1	2.70
19	M.Deepa	IIT-Hyderabad	Chemistry	34	335	9.85	11	2	5.88
20	A.Ekbal	IIT-Pata	Computer	33	75	2.27	5	3	9.09
21	N.K.Nishchal	IIT-Patna	Physics	33	318	9.64	11	3	9.09
22	V.Kanchana	IIT-Hyderabad	Physics	30	119	3.97	7	15	50.00
23	R.Mara	IIT-Indore	Chemistry	30	441	14.70	13	0	0.00
24	K.C.Sahu	IIT-Hyderabad	Chemical Engineering	28	180	6.43	9	14	50.00
25	R.B.Pachori	IIT-Indore	Engineering	28	227	8.11	8	2	7.14
26	R. Jha	IIT-Bhubaneswar	Phys	28	189	6.75	7	3	10.71
27	M. Chakrborty	IIT-Bhubaneswar	MechEngn	26	96	3.69	7	3	11.54
28	T.K.Panda	IIT-Hyderabad	Chemistry	25	180	7.20	9	7	28.00
29	P.Kumar	IIT-Patna	Electrical	25	42	1.68	3	1	4.00
30	B.Jayaram	IIT-Hyderabad	Math	24	52	2.17	3	10	41.67
31	A.Acharyya	IIT-Hyderabad	Electrical	23	36	1.57	3	15	65.22
32	S.G.Singh	IIT-Hyderabad	Electrical	23	47	2.04	4	1	4.35
33	M.Kar	IIT-Patna	Physics	23	112	4.87	5	2	8.70
34	A.K.Thakur	IIT-Patna	Chemistry	23	62	2.70	4	10	43.48
35	S.K.Gupta	IIT-Patna	Math	21	86	4.10	6	4	19.05
	Total of 35 authors			1524	18321	12.02	10.84	746	48.95
	Total of all IITs			3656	16913				
	Share of 35 authors in total output of new IITs			41.68					

Table 24: Distribution of New IITs papers in Top 35 Most Productive Journals, 2010-14

S.No	Name of the Journal	TP	SJR	Hyd	Indore	Patna	Bhub	Ropar	Gandhi	Mandi	Jodh
1	RSC Advances	72	1.03	11	21	17	0	14	2	7	0
2	Dalton Transactions	41	1.28	5	22	1	3	4	1	5	0
3	Tetrahedron Letters	37	0.72	12	2	3	2	15	0	3	0
4	Journal of Applied Physics	36	0.91	11	6	1	8	1	2	6	1
5	Applied Physics Letters	32	1.62	7	10	0	12	0	0	1	2
6	Tetrahedron	27	0.87	7	6	1	4	6	0	3	0
7	Physical Review Letters	22	4.4	0	16	0	0	3	3	0	0
8	Physics Letters, Section B	22	3.2	0	22	0	0	0	0	0	0
9	Physical Review D	21	2.04	6	3	0	1	0	9	0	2
10	Journal of Physical Chemistry C	20	1.86	7	5	4	0	2	0	1	1
11	Physical Review B	19	2.33	6	2	2	6	0	0	3	1
12	Journal of Organometallic Chemistry	18	0.64	5	11	0	1	1	0	0	0
13	Physical Review C	17	2.14	0	11	0	0	6	0	0	0
14	Physical Chemistry Chemical Physics	16	1.61	5	6	2	0	1	0	2	0
15	Physical Review E	16	1.03	4	5	0	1	2	2	0	2
16	Metallurgical and Materials Transactions A	15	1.58	5	0	0	2	7	0	1	0
17	Journal of Organic Chemistry	15	1.78	5	3	0	7	0	0	0	0
18	Sensors and Actuators, B: Chemical	14	1.16	2	0	0	5	6	0	1	0
19	Journal of Materials Science: Materials in Electronics	13	0.55	3	4	2	2	1	0	0	1
20	European Physical Journal C	12	1.05	0	11	0	1	0	0	0	0
21	ACS Applied Materials and Interfaces	12	1.96	4	0	4	1	0	0	3	0
22	Journal of Micromechanics &Microengineering	12	0.73	12	0	0	0	0	0	0	0
23	Physical Review A	12	1.83	1	0	1	1	0	1	2	6
24	Inorganic Chemistry	12	1.68	2	7	0	0	2	1	0	
25	Materials and Manufacturing Processes	12	0.96	4	5	0	1	2	0	0	0
26	Journal of Alloys and Compounds	12	1.09	6	1	3	0	2	0	0	0
27	Materials Letters	11	0.85	1	0	0	3	5	0	2	0
28	Journal of Physics Condensed Matter	11	1.09	4	0	0	2	0	0	5	0
29	International Journal of Hydrogen Energy	11	1.14	4	5	0	0	0	2	0	0
30	Chemical Engineering Journal	11	1.59	6	0	0	0	0	5	0	0
31	Expert Systems with Applications	11	2.00	0	3	2	4	1	0	1	0
32	Journal of Molecular Structure	10	0.41	7	0	2	1	0	0	0	0
33	Journal of Thermal Spray Technology	10	0.8	0	0	0	1	9	0	0	0
34	Journal of High Energy Physics	10	0.98	0	6	0	3	0	1	0	0
35	Journal of Materials Science	9	0.93	1	0	8	0	0	0	0	0

each), A. Gupta, R. Raniwalah and P.K. Sahoo (64 papers each), U.B. Desai (52 papers), A. Bowmick (47 papers) and S.N. Merchant (44 papers) during 2010-14.

The average citation per paper registered by all 35 authors was 12.02 and 11 authors have registered more than the average citation per paper of all authors: A.Gupta, R.Raniwalah and P.K. Sahoo (22.13 each), D.P. Mahaptra (21.80), T.K. Nayak (21.78), B.K.Nandi (21.34), R. Verma (20.91), R. Sahoo (20.59), A.N.Mishra (19.42), R. Mara (14.70) and A. Bowmick (13.30) during 2010-14. The average h-index by all 35 authors was 10.87 and 16 authors have registered more than the average h-index of all authors: B.K. Nandi and R.Verma (25 each), A. Gupta, R. Raniwalah, P.K. Sahoo, D.P. Mahaptra, T.K. Nayak, R. Sahoo and A.N. Mishra (23 each), N.Singh (16), S.M. Mobin (14), R. Mara, A.Bowmick, M. Deepa, N.K. Nishchal and C. Subrahmanyam (11 each) during 2011-14. The average share of international collaborative papers (ICP) of all 35 authors was 48.95% and 11 authors have registered more than the average ICP of all authors: R.Verma, A.Gupta, R.Raniwalah and T.K.Nayak (100.0%), B.K.Nandi (98.63%), D.P. Mahaptra (98.46%), A.N.Mishra (96.92%), R.Sahoo (95.65%), A. Acharya (65.22%), K.C. Sahu and V. Kanchana (50.0% each) during 2010-14.

Medium of Communication

The eight new IITs scholars had contributed 660 papers, published them in top 35 most productive journals as shown in Table 24. These 660 papers constituted 16.41% share of New IITs total output during 2010-14. Most of these reporting journals had high impact factor with SJR varying from 0.41 to 4.40. New IITs published the largest number of their papers (70) in *RSC Advances*, Tetrahedron Letters (44 papers), Dalton Transactions (40 papers), etc. The distribution of papers in these top 35 journals by individual IITs is also shown in Table 24.

Highly Cited Papers

Among 660 papers, 26 were highly cited papers with 50+ citations per paper (17 papers with citation range 50-99 and 9 with citation range 100 to 276). These highly cited papers together received 2392 citations, with an average of 92.0 citations per paper. Among these highly cited papers, IIT-Indore contributed the largest number (11), followed by IIT-Ropar (5 papers), IIT-Patna, IIT-Bhubaneswar and IIT-Gandhinagar (3 papers each), IIT-Jodhpur (1 paper). These 26 highly cited papers involved 35 authors from 8 new IITs, of which the largest contribution (8 papers

each) came from A.Gupta, A.N.Mishra, D.P.Mahapatra, B.K.Nandi, R.Sahoo, P.K.Sahu, R.Raniwala, S.Raniwala and R.Varma, followed by A.K.Bhowmick and P.Bhunia (2 papers each) and other others with 1 paper each. These 26 highly cited papers were published in 20 journals, with largest number of papers (4) came from *Physical Review Letters*, followed by 2 papers each in *Physical Review C, Physics Letters, Section B* and *Progress in Polymer Science* and 1 paper each in 15 other journals.

Summary and Conclusions

This study analyses research publications output of eight new IITs to understand their comparative performance in research during 2010 - 14. The study finds that research across eight new IITs is growing but at uneven rates ranging from a high of 348.10% in IIT-Mandi to a low of 51.11% in IIT-Ropar during 2010-14. Total contributions of all eight IITs averaged 68.78% growth per annum, increasing from 184 in the year 2010 to 1408 publications in 2014.

New IITs differ widely in their citation impact (2.654 ~ 6.72), with highest (6.72 and 6.58) registered by IIT-Ropar and IIT-Indore, followed by IIT-Bhubaneswar (4.93), IIT-Patna (3.82), IIT-Hyderabad (3.64), IIT-Gandhinagar (3.61), IIT-Mandi (3.37) and IIT-Jodhpur (2.654) during 2010-14. Eight new IITs averaged their citation impact to 4.63 citations per paper.

Eight new IITs undertake collaborative research at national and international level. Nearly 35.39% of their total output resulted from national collaboration. IIT-Jodhpur contributed the largest share of collaborative output (52.02%), followed by IIT-Bhubaneswar (44.44%), IIT-Ropar (38.20%), IIT-Patna (36.65%), IIT-Hyderabad (35.84%), IIT-Gandhinagar (30.94%), IIT-Mandi (27.31%) and IIT-Indore (24.96%) during 2010-14. Nearly 28.34% of their total output resulted from international collaboration. IIT-Mandi (41.60%) contributed largest share of international collaborative papers, followed by IIT-Gandinagar (41.04%), IIT-Indore (31.72%), IIT-Ropar (31.01%), IIT-Bhubaneswar (26.55%), IIT-Jodhpur (23.70%) and IIT-Patna (14.06%) during 2010-14.

Most productive areas of new eight IITs were: engineering with 34.85% share, followed by physics & astronomy (27.05%), computer science (22.16%), materials science (22.16%) and chemistry (18.90%). But in terms of quality of research chemistry ranked highest with 8.30 citations per paper, followed by physics & astronomy (6.11), materials

science (5.35), engineering (3.49) and computer science (1.92) during 2010-14.

Medium-sized productive areas of eight IITs were: mathematics (11.41%), chemical engineering (9.05%), energy 6.35%), biochemistry (6.18%), genetics& molecular biology (5.44%), social sciences (6.18%) and medicine (4.68%). Biochemistry, genetics & molecular biology registered the highest impact of 8.42 citations per paper, followed by chemical engineering (6.82), medicine (6.01), energy (5.20), mathematics (2.83) and social sciences (1.34) during 2010-14.

Least productivity areas of eight areas were: environment science (3.12%), earth & planetary sciences (2.82%), pharmacology (2.16%), toxicology (0.93%), agricultural & biological sciences (0.63%) and neurosciences during 2010-14. Pharmacology, toxicology and pharmaceutical science registered the highest citation per paper (12.53) among these five subject areas, followed by the environment science (7.01), neurosciences (6.22), agricultural & biological sciences (4.24) and earth & planetary sciences (2.81) during 2010-14.

The study identified 35 significant authors across 8 new IITs (13 affiliated to IIT-Indore, 10 to IIT-Hyderabad, 8 to IIT-Patna, 3 to IIT-Bhubaneswar and 1 to IIT-Ropar) with their contributions from 21 to 82 publications per author, and together they contributed 1524 publications with 41.68% share of IITs total output during 2010-14. Amongst these 35 authors, 13 were in physics, 7 in chemistey, 6 in electrical engineering, 3 in computer science, 2 each in chemical engineering and mathematics and 1 each in engineering and mechanical engineering. These 35 authors from eight new IITs together published 660 papers in top 35 most productive journals (with high impact factor journals with SJR varying from 0.41 to 4.40 varying from 0.720 to 11.36). These 35 journals accounted for 43.35% share of their total output during 2010-14.

The study identified 26 highly cited papers each with 50 or more citations (17 papers in citation range 50-99 and 9 papers in citation range 100 to 276 per paper) and together these papers cumulated 2392 citations, averaging 92.0 citations per paper. IIT-Indore contributed the largest number of highly cited papers (11), followed by IIT-Ropar (5 papers), IIT-Patna, IIT-Bhubaneswar and IIT-Gandhinagar (3 papers each), and IIT-Jodhpur (1 paper). These 26 highly cited papers involved 35 authors from 8 new IITs, of which the largest contribution (8 papers each) came from A.Gupta, A.N.Mishra, D.P.Mahapatra, B.K.Nandi, R.Sahoo, P.K.Sahu, R.Raniwala, S.Raniwala

and R.Varma, followed by A.K.Bhowmick and P.Bhunia (2 papers each), etc.

Suggestions

Significant differences are observed across new IITs in terms of their research output. IIT-Jodhpur, IIT-Mandi and IIT Gandhinagar need significant improvement in their research publications volume, research growth, citation numbers, and number of national and international collaborative papers. All new IITs except IIT-Ropar and IIT-Indore need to improve their citation impact rates. IIT-Jodhpur, IIT-Patna and IIT-Mandi need to focus more on improving their performance in particular in international collaborations. New IITs are doing good research in Sceince, Engineering and Technology and there is a good scope to expand research in Humanties and Social Sciences also. IIT-Jodhpur, IIT-Mandi and IIT-Gandhinagar needs to improve their share of most productive authors across all the disciplines.

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APPENDIX 1

LIST OF TOP 26 HIGH CITED ARTICLES
(Authors from IIT are marked as bold)

1. Sengupta, R., Bhattacharya, M., Bandyopadhyay, S., **Bhowmick, A.K.**
A review on the mechanical and electrical properties of graphite and modified graphite reinforced polymer composites (Review). *Progress in Polymer Science (Oxford)*, 2011, 36 (5), 638-670. Cited 276 times. Indian Institute of Technology, Rubber Technology Centre, Kharagpur, 721302, India UNSW, Sydney, [b] School of Materials Science and Engineering, NSW 2052, Australia **Indian Institute of Technology, Patna, 800013, India**

2. **Verma, A.K., Dash, R.R., Bhunia, P.**
A review on chemical coagulation/flocculation technologies for removal of colour from textile

wastewaters (Review). *Journal of Environmental Management*, 2012, 93 (1), pp. 154-168. Cited 170 times.

Indian Institute of Technology,Department of Civil Engineering, School of Infrastructure, Bhubaneswar, Orissa 751 013, India

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    INRS Eau, Terre, Environnement, Québec, Canada
    Indian Institute of Technology, Dept. of Civil Engineering, Bhubaneswar, India
    GMSC, NB, Canada
    US Environmental Protection Agency, Kansas City, KS, USA

4. Abelev, B., **Gupta, A.,Mahapatra, D.P.,Nath Mishra, A**., **Nandi, B.K.,A.R., Raniwala, R., Raniwala, S.**, **Sahoo, R.,Sahu, P.K.,Varma, R. et al.** Long-range angular correlations on the near and away side in p-Pb collisions at √sNN=5.02 TeV (Article). *Physics Letters, Section B: Nuclear, Elementary Particle and High-Energy Physics*, 2013, 719 (1-3), pp. 29-41. Cited 159 times.

    A. I. Alikhanyan National Science Laboratory, Yerevan Physics Institute) Foundatio, Yerevan, Armenia
    Indian Institute of Technology Indore (IITI), Indore, India et al

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    Indian Institute of Technology, Gandhinagar, Department of Chemical Engineering, Ahmedabad, Gujarat, India

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    Indian Institute of Technology Indore,[i] Department of Chemistry, IET, DAVV Campus, Khandwa Road, Indore 452017, India et al

7. Sahu, S.S., **Panda, G.A** novel feature representation method based on Chou's pseudo amino acid composition for protein structural class prediction (Article), *Computational Biology and Chemistry*, 2010, 34 (5-6), pp. 320-327. Cited 115 times.

National Institute of Technology, Department of Electronics and Communication Engineering, Orissa, India
Indian Institute of Technology, School of Electrical Sciences, **Orissa, India**

8. Abelev, B., **Gupta, A.,Mahapatra, D.P**., **Mishra, A.N**., **Nandi, B.K.,Raniwala, S., Raniwala, R**., **Sahoo, R.,Sahu, P.K.,Varma, R.** et al. J/ψ suppression at forward rapidity in Pb-Pb collisions at √sNN=2.76TeV (Article). *Physical Review Letters*, 2012, 109 (7), art. no. 072301. Cited 105 times.

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9. Taylor, R., Coulombe, S., Otanicar, T., Phelan, P., Gunawan, A., Lv, W., Rosengarten, G., Prasher, R., **Tyagi, H.**Small particles, big impacts: A review of the diverse applications of nanofluids (Review). *Journal of Applied Physics*, 2013, 113 (1), art. no. 011301, . Cited 101 times.

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    Indian Institute of Technology Department of Computer Science and Engineering, Ropar, Rupagnar, 140001, Indiaet al

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    Indian Institute of Technology, Department of Chemistry, Patna 800013, India

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    Indian Institute of Technology, Department of Chemistry, Ropar, Rupnagar, Panjab 140001, India

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