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FRONTIERS IN RADIO ASTRONOMY RESEARCH IN INDIA (1999-2012): A SCIENTOMETRIC STUDY

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Abstract: This study discusses the research performance and productivity of India institutions in its publications reflected in Science Citation Index Expanded in the field of Radio Astronomy research during the year 1999-2012. The Indian publications have grown steadily from 4.357% (298) in 1999 to 11.9% (814) publications in 2012. Among top ten Indian Institutes IUCAA ranks first with highest h-index 67, followed by TIFR with 58 h-index, IIAP with 39 h-index, RRI and Panjab University with 35 h-index each.

Keywords: Scientometrics, Radio Astronomy, Research performance.

INTRODUCTION:

The assessment of research performance of countries, region, institution and individuals based on counting of publications and citations are prominent in studies of science and in research policy for identification and evaluation of the strength and weakness in scientific achievements. As growth in scientometric techniques like publication profile of institutions, individuals, countries etc are closely related to overall R & D development of a country, scientometric studies are primarily intended to identify, compare and evaluate relevant aspects of input and output of scientific productivity and research in more objectives that is quantitative fashion.

From the dawn of civilization, astronomy has provided important stepping-stones for human progress. Astronomy is not only the oldest of all sciences, but it can also be called the fountainhead of all sciences (Abhyankar, 2007). Astronomy in India was well developed in ancient times culminating in the writing of Surya Siddhanta in the fifth century. Astronomy is one of the branches of science that have had much stimulus to its advancement by virtue of the contributions made by early Indian thinking (Kochhar, 1991). In recent years an increasing attention has been paid to the social dimensions of scientific community that produces sciences. But this unprecedented growth in literature has become a major concern for the scientists, scholars, and library professional as they try to keep themselves abreast with new advances in their subject, and information professionals try to organize this knowledge. How the growth, origin and language of literature reflect in various national level activities in R&D is a matter of great concern to the managers of the scientific activities in government, industry and in academic community.

2.OBJECTIVES

The main objectives are as follows

- To study the growth of literature in radio astronomy research;
- To study the productivity of Indian institutions;
- To study the year wise publications of Ten most productive Indian institutions;

- To study the International collaboration.

3.METHODOLOGY

The data for the study were retrieved from Web of Science, Science Citation Index Expanded (SCIE) subject category Astronomy and Astrophysics, within that records pertaining to radio astronomy were collected for the year 1999-2012. Data was analyzed using MS excel as per the adjectives of the study. We calculated index h, to characterize the significance of the scientific output of a researcher/institution has stirred a wave of comment of planetary proportions, as proposed by Hirsch, The index h, defined as the number of papers with citation number higher or equal to h, as a useful index to characterize the scientific output of a researcher (Hirsch, 2005).

To evaluate the performance level of research of an institute, an index called Participative Index (PaI) (Garcia, 2005) has been calculated. PaI is the ratio of the number of papers generated in a country or institution and the total number of documents collected in this repertoire.

PaI can be calculated using formula:

$$PaI = \frac{No.of\ papers\ generated\ in\ an\ institution}{Total\ number\ of\ documents\ collected\ in\ this\ reperoire} X\ 100$$

4.RESULTS AND DISCUSSION

4.1 Growth pattern of Publication

Year-wise distribution of total research output in the field of Radio Astronomy research is captured in the Table 1 and depicted in figure 1. It is observed that the output of world as whole has grown steadily during the period of study from 11,509 (5.88%) publications in the year 1999 to 17,163 (8.767%) publications in the year 2012, while for Indian publications also grown steadily with 4.357% (298) in 1999 to 11.9% (814) publications in the year 2012, except in the year 2003-2005.

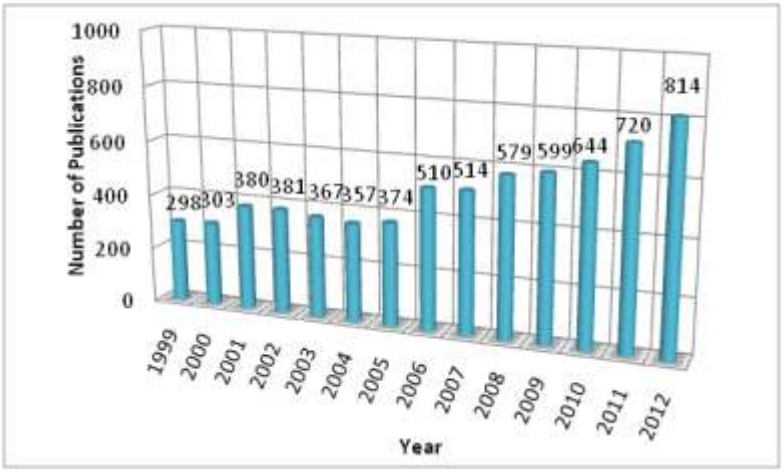

Figure 1 Year wise publications by Indian scientists during 1999-2012

Table 1 Year wise publications by World and India

Year	World Output	Cumulative	India	Cumulative
1999	11509	11509	298	298
2000	11278	22787	303	601
2001	12295	35082	380	981
2002	12312	47394	381	1362
2003	13031	60425	367	1729
2004	13954	74379	357	2086
2005	13580	87959	374	2460
2006	14191	102150	510	2970
2007	14153	116303	514	3484
2008	14929	131232	579	4063
2009	15600	146832	599	4662
2010	15424	162256	644	5306
2011	16349	178605	720	6026
2012	17163	195768	814	6840
Total	**195768**		**6840**	

4.2 Productivity of Indian Institutions

India is rich in higher learning and it has research resources in the form of R & D institutions, libraries, universities, archives, government department etc. The R & D activity taken up by these organizations are being reported in the form of articles, books, people, etc. Evaluation is a very important component of R & D activity in a country as they direct the policy makers how and where the R & D investment, policies and programmes has to be made. Information providers, whether human resources or organizations, engaged in research work, play a vital role in scientific and technological development of the country. In order to understand the progress and contributions of R & D institutions, their publication profile /paper productivity can be measured. The practice of assessing the productivity of S & T institutions based on their publication by using sceintometric technique is being used these since long.

Table 2 Most Productive Indian Institutions

Sl.No.	Institution Name	Publications	%
1	TATA INSTITUTE OF FUNDAMENTAL RESEARCH	1210	17.69
2	INTER UNIVERSITY CENTRE FOR ASTRONOMY ASTROPHYSICS	824	12.047
3	INDIAN INST ASTROPHYS	774	11.316
4	PHYSICAL RESEARCH LABORATORY INDIA	467	6.827
5	INDIAN INSTITUTE OF TECHNOLOGY IIT	412	6.023
6	RAMAN RES INST	391	5.716
7	INDIAN INSTITUTE OF SCIENCE IISC BANGLORE	258	3.772
8	PANJAB UNIVERSITY	223	3.26
9	HARISH CHANDRA RES INST	221	3.231
10	JADAVPUR UNIVERSITY	212	3.1
11	ARYABHATTA RESEARCH INSTITUTE OF OBSERVATIONAL SCIENCES	195	2.851
12	VIKRAM SARABHAI SPACE CENTER VSSC	182	2.661
13	SN BOSE NATIONAL CENTRE FOR BASIC SCIENCE	173	2.529

14	SAHA INSTITUTE OF NUCLEAR PHYSICS	172	2.515
15	UNIVERSITY OF DELHI	148	2.164
16	INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE IACS JADAVPUR	140	
17	UNIVERSITY OF PUNE	131	1.915
18	BANARAS HINDU UNIVERSITY	130	1.901
19	NATL CTR RADIO ASTROPHYS	123	1.798
20	INDIAN INSTITUTE OF GEOMAGNETISM	121	1.769
21	ISRO	108	
22	BHABHA ATOMIC RESEARCH CENTER	82	1.199
23	UNIVERSITY OF CALCUTTA	81	1.184
24	COMMONWEALTH SCIENTIFIC INDUSTRIAL RESEARCH ORGANISATION CSIRO	74	1.082
25	COUNCIL OF SCIENTIFIC INDUSTRIAL RESEARCH CSIR INDIA	74	1.082
26	JAMIA MILLIA ISLAMIA	69	1.009
27	NATL ATMOSPHER RES LAB	60	0.877
28	INDIAN CTR SPACE PHYS	45	0.658
29	UTTAR PRADESH STATE OBSERV	44	0.643
30	CTR SPACE PHYS	43	0.629
31	UNIVERSITY OF HYDERABAD	36	0.526
32	ALIGARH MUSLIM UNIVERSITY	35	0.512
33	BENGAL ENGINEERING SCIENCE UNIVERSITY	35	0.512
34	UNIV RAJASTHAN	35	0.512
35	OSMANIA UNIVERSITY	34	0.497
36	UNIVERSITY OF MUMBAI	33	0.482
37	INDIAN STATISTICAL INSTITUTE	31	0.453
38	NORTH BENGAL UNIVERSITY	30	0.439
39	SAMBALPUR UNIV	30	0.439
40	ASSAM UNIV	28	0.409
41	N BENGAL UNIV	27	0.395
42	VISVA BHARATI UNIV	27	0.395
43	HINDU POSTGRAD COLL, Gaziabad	26	0.38
44	MADURAI KAMARAJ UNIV	26	0.38
45	UNIVERSITY OF CALICUT	26	0.38
46	UNIVERSITY OF GORAKHPUR	26	0.38
47	MANIPUR UNIVERSITY	25	0.365
48	MEHTA RES INST, Allahabad	23	0.336
49	NORTH EASTERN HILL UNIVERSITY	22	0.322
	Truncated		

The most productive Indian institutions are showed in table 2. The Tata Institute of Fundamental Research (TIFR), Mumbai contributed highest publications of 1210 (17.69 %) in the field of radio astronomy literature, followed by Inter University Centre for Astronomy Astrophysics (IUCAA), Pune with 824 (12.04 %), Indian Institute of Astrophysics (IIAP), Bengaluru with 774 (11.31 %), Physical Research Laboratory India with 467 (6.82 %). Among Indian Universities, Panjab University ranks first which contributed 223 (3.26 %) in the field of radio astronomy literature, followed by Jadavpur University with 212 publications, University of Delhi with 148 (2.164 %).

4.3 Most Productive foreign Institutions which are collaborated with Indian institutions

Table 3 shows that the most productive foreign institutions which are collaborated with Indian institutions, it clearly shows that Indian institutions are collaborated more with USA (58.9%) based institutions compared to countries. Max Planck Society, Germany ranks first among foreign intuitions with 381 (5.57%) collaborative publications, followed by Atomic Energy Alternative Energies Commission CEA, France with 242 (3.53%), University System of Maryland, USA with 221(3.231%), University of Maryland College Park, USA with 216 (3.158%) collaborative publications respectively.

Table 3 Most Productive foreign Institutions which are collaborated with Indian institutions

Sl.No.	Institution Name	Country	Publications	%
1	MAX PLANCK SOCIETY	GERMANY	381	5.57
2	ATOMIC ENERGY ALTERNATIVE ENERGIES COMMISSION CEA	FRANCE	242	3.538
3	UNIVERSITY SYSTEM OF MARYLAND	USA	221	3.231
4	UNIVERSITY OF MARYLAND COLLEGE PARK	USA	216	3.158
5	ALIKHANOV INSTITUTE FOR THEORETICAL EXPERIMENTAL PHYSICS	RUSSIA	199	2.909
6	FLORIDA STATE UNIVERSITY SYSTEM	USA	196	2.865
7	INST HIGH ENERGY PHYS	RUSSIA	190	2.778
8	PRINCETON UNIVERSITY	USA	183	2.675
9	UNIVERSITY OF CINCINNATI	USA	183	2.675
10	CNRS	FRANCE	179	2.617
11	GODDARD SPACE FLIGHT CENTER	USA	178	2.602
12	MASSACHUSETTS INSTITUTE OF TECHNOLOGY MIT	USA	178	2.602
13	COLUMBIA UNIVERSITY	USA	177	2.588
14	UNIVERSITY OF CHICAGO	USA	173	2.529
15	UNIVERSITY OF WISCONSIN SYSTEM	USA	173	2.529
16	UNIVERSITY OF CALIFORNIA BERKELEY	USA	172	2.515
17	UNIVERSITY OF SCIENCE TECHNOLOGY CHINA	CHINA	172	2.515
18	UNIVERSITY OF TEXAS AUSTIN	USA	172	2.515
19	UNIVERSITY OF ROCHESTER	USA	171	2.5
20	NORTHWESTERN UNIVERSITY	USA	167	2.442
21	UNIVERSITY OF SYDNEY	AUSTRALIA	164	2.398
22	SEOUL NATIONAL UNIVERSITY	SOUTH KOREA	161	2.354
23	UNIVERSITY OF MELBOURNE	AUSTRALIA	160	2.339
24	IOWA STATE UNIVERSITY	USA	159	2.325
25	STATE UNIVERSITY OF NEW YORK SUNY SYSTEM	USA	157	2.295
26	UNIVERSITY OF HAWAII SYSTEM	USA	157	2.295
27	CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	SPAIN	154	2.251
28	NATIONAL CENTRAL UNIVERSITY	TAIWAN	154	2.251
29	UNIVERSITY OF ILLINOIS SYSTEM	USA	154	2.251
30	UNIVERSITY OF MANCHESTER	ENGLAND	154	2.251
31	NAGOYA UNIVERSITY	JAPAN	153	2.237
32	STANFORD UNIVERSITY	USA	148	2.164
33	FOM NATIONAL INSTITUTE FOR SUBATOMIC PHYSICS	NETHERLANDS	147	2.149
34	NATIONAL INSTITUTES OF NATURAL SCIENCES NINS JAPAN	JAPAN	147	2.149
35	SUNGKYUNKWAN UNIVERSITY	SOUTH KOREA	147	2.149
36	UNIVERSITY OF MISSISSIPPI	USA	147	2.149
37	NATIONAL ASTRONOMICAL OBSERVATORY OF JAPAN	JAPAN	146	2.135
38	HIGH ENERGY ACCELERATOR RESEARCH ORGANIZATION KEK	JAPAN	145	2.12
39	IMPERIAL COLLEGE LONDON	ENGLAND	145	2.12
40	UNIVERSITY OF NOTRE DAME	USA	142	2.076

41	JOHNS HOPKINS UNIVERSITY	USA	140	2.047
42	OSAKA CITY UNIVERSITY	JAPAN	136	1.988
43	PENNSYLVANIA COMMONWEALTH SYSTEM OF HIGHER EDUCATION PCSHE	PENNSYLVANIA	136	1.988
44	UNIVERSITY OF LOUISIANA SYSTEM	USA	134	1.959
45	ISTITUTO NAZIONALE DI FISICA NUCLEARE		132	1.93
46	LOUISIANA TECHNICAL UNIVERSITY	USA	132	1.93
47	YONSEI UNIVERSITY	SOUTH KOREA	131	1.915
48	STFC RUTHERFORD APPLETON LABORATORY	ENGLAND	130	1.901
49	KYUNGPOOK NATIONAL UNIVERSITY	SOUTH KOREA	128	1.871
50	NATIONAL TAIWAN UNIVERSITY	TAIWAN	127	1.857
	Truncated			

4.4 Year wise Publications of Ten Most Productive Indian Institutions

Year wise publications of ten most productive Indian Institutions are showed in figure 2 and depicted in table 4. It is observed that among top ten Indian Institutes IUCAA ranks first with highest h-index 67, followed by TIFR with 58 h-index, IIAP with 39 h-index, RRI and Panjab University with 35 h-index each.

TIFR ranks fist in order contributing 17.65% of PaI, followed by IUCAA 12.05% of PaI in total research output, IIAP with 11.31% of PaI. The other institutes got less than ten percent of PaI. This variation may be due to less output during the study period.

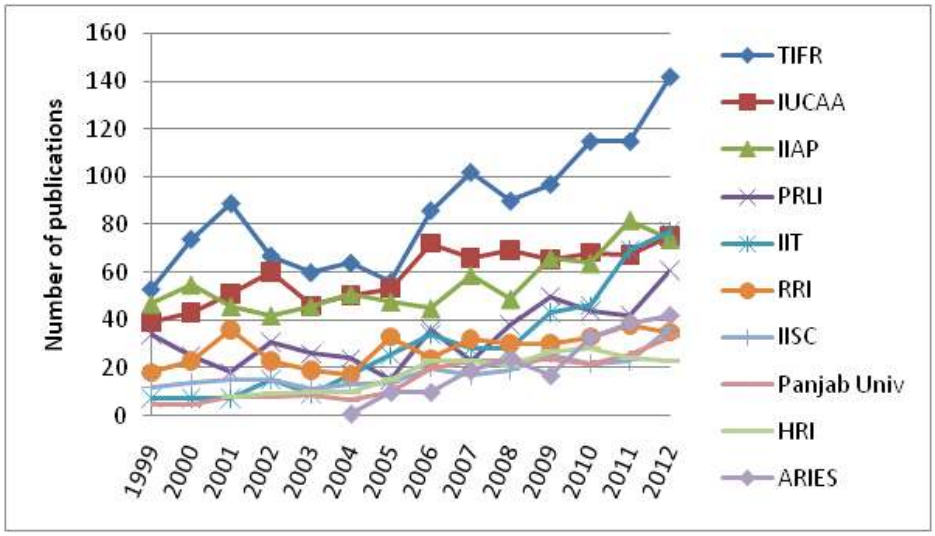

Figure 2 Year wise publications of top Ten Indian Institutions

Table 4 Year wise Publications of Ten Most Productive Indian Institutions

Year	IIAP	IISC	IIT	IUCAA	PRLI	RRI	TIFR	Panjab Univ	HRI	ARIES
1999	47	12	7	39	34	18	53	5		
2000	55	14	7	43	25	23	74	5		
2001	46	15	7	51	18	36	89	8	8	
2002	42	15	15	60	31	23	67	8	9	
2003	46	11	9	46	26	19	60	9	10	
2004	51	13	17	50	24	17	64	7	10	1
2005	48	14	25	53	15	33	56	10	15	10

2006	45	20	34	72	36	24	86	20	23	10
2007	59	17	28	66	23	32	102	23	23	19
2008	49	19	28	69	38	30	90	23	21	24
2009	66	26	43	65	50	30	97	24	27	17
2010	64	22	46	68	44	33	115	22	28	33
2011	82	23	69	67	42	38	115	26	24	39
2012	74	37	77	75	61	35	142	33	23	42
Total	**774**	**258**	**412**	**824**	**467**	**391**	**1210**	**223**	**221**	**195**
TCR*	9081	3542	4051	21480	4239	5771	24923	4662	3688	1746
ACP*	11.73	13.73	9.83	26.07	9.08	14.76	20.60	20.91	16.69	8.95
PaI*	11.32	3.77	6.02	12.05	6.83	5.72	17.69	3.26	3.23	2.85
h-index	**39**	**29**	**29**	**67**	**27**	**35**	**58**	**35**	**30**	**22**

* TCR=Total citations received; ACP=Average Citations per Paper; PaI=Participative Index

The citation received by the Indian institutions showed in figure 3. TIFR received 24923 citations for the 1210 publications with 20.60 average citations per paper (ACP), followed by IUCAA received 21480 citations for 824 papers with 26.07 ACP, IIAP received 9081 citations for 774 publications with 11.73 ACP, RRI received 5771 citations for 391 publications with 14.76 average citations per paper.

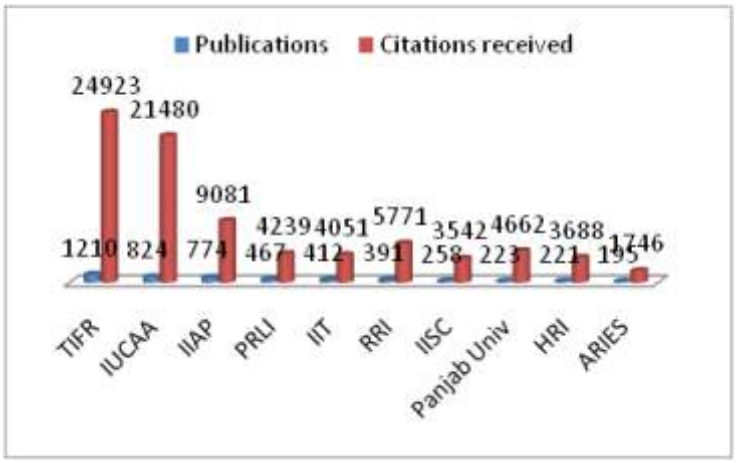

Figure 3 Citations received by the Indian institutions

4.5 Country wise collaboration with ten most productive Indian Institutes

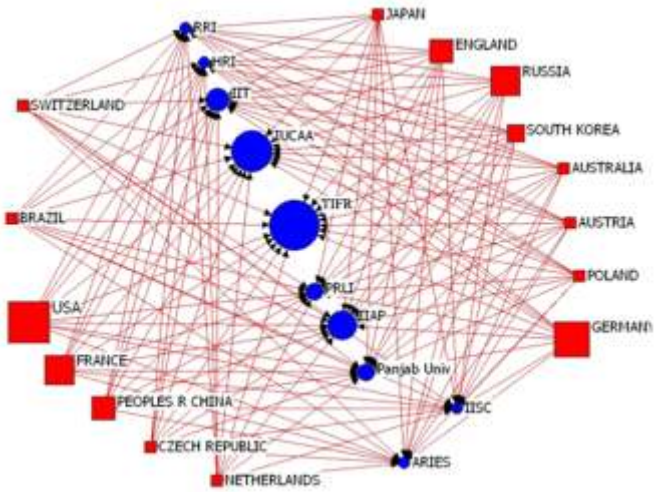

Figure 4 International Collaboration with most productive Indian institutes.

From the table 5 and figure 4, it can be observed that TIFR is having most collaborative frequencies with foreign countries, 538 collaborative papers with USA, 263 with Germany, 194 collaborative papers with Russia. IUCAA having 221, IIAP having 208, Panjab University having 204 collaborative publications with USA respectively, followed by IUCAA having 133, IIT having 104, IIAP having 84, Panjab University having 151 collaboration frequencies with Germany respectively.

Table 5 Country wise collaboration of ten most productive Indian Institutes

Country	TIFR	IUCAA	IIAP	PRLI	IIT	RRI	IISC	Panjab Univ	HRI	ARIES
USA	538	221	208	102	160	109	53	204	27	67
GERMANY	263	133	84	48	104	33	14	151	19	26
RUSSIA	194	99	21	10	87	11	1	203	1	21
FRANCE	191	164	72	41	71	50	25	97	5	24
PEOPLES R CHINA	185	28	22	15	34	5	3	200	4	14
SOUTH KOREA	182	17	22	13	34	4	2	202	6	18
JAPAN	179	97	80	21	29	20	11	117	12	30
ENGLAND	165	136	48	24	81	26	7	89	6	21
POLAND	148	34	7	3	34	6	1	144	3	11
AUSTRALIA	140	83	19	4	24	39	1	110	1	6
SWITZERLAND	138	9	17	7	26	3	6	144	3	2
TAIWAN	121	4	24	6	21	1	5	123	5	18
NETHERLANDS	117	34	21	13	63	26	5	77	8	4
CZECH REPUBLIC	109		4	1	33			112	1	2
BRAZIL	101	11	22	16	12			94		2
AUSTRIA	100	2	6	8	23		1	110		4
CANADA	95	37	13	5	68	11	4	46	5	4
ITALY	95	87	56	39	69	23	8	38	11	20
SPAIN	95	80	66	27	59	12	7	42		18
MEXICO	94	10	21	3	5	6	3	86		2
SLOVENIA	87	1	5		21			104		1
SWEDEN	82	23	10	7	7	1	1	55	4	5
COLOMBIA	81		1	1				83	1	
ECUADOR	71							71		
ARGENTINA	68	2	4					65		6
IRELAND	67	8	10	4		1	2	56	2	4
CHILE	26	53	15	11		2	2			16
PORTUGAL	25	3	4	8	2			11	1	3
FINLAND	23	2	6	10	3	1		17	2	2
GREECE	18	4	2	1	4	2		18		1
HUNGARY	16	31	3	2	3	2	2	16		1
BELGIUM	15	6	12	8			1	11		4
SCOTLAND	14	66	4	1	52	2	1	6		1
EGYPT	13	1			2			10		
BULGARIA	12		3	1				13	1	10
CYPRUS	12							13		
NEW ZEALAND	12	2		2		1		10	1	1
ARMENIA	11				3			13		2
DENMARK	11	14	14	1	5	1		3	1	4
CROATIA	10				11			21	3	1
SOUTH AFRICA	10	8	4	9	4	1	2	3		4
TURKEY	10	1	1	1	1	1		11		4
SERBIA	9		1		1			11		
UKRAINE	9	15	12	3	3	6	1	14		7
BYELARUS	8							10		
ESTONIA	8							10		
IRAN	8	12	1			1		10		
LITHUANIA	8			3				10		2
PAKISTAN	8							10		

REP OF GEORGIA	8		3	1		1		10	1	4
ROMANIA	7		4	3	3		4	10		
WALES	6	72	4	3	4	18	5		1	
ISRAEL	4	5	3	2	54	1	1	1	2	
SLOVAKIA	4		1		3			7		2
SAUDI ARABIA	3	1								
NORWAY	2	4	7	2	56			3		
TRINID TOBAGO	2									
COSTA RICA	1		1							
ICELAND	1	2	1	1		1				1
NORTH IRELAND	1	2	30			1	1			5
THAILAND	1	2						1		
VENEZUELA	1		3			1				2
CUBA					3			3		
FIJI				1						2
KAZAKHSTAN			2					1		
LATVIA			1							
LEBANON			1			1				2
MAURITIUS			2			9				
MYANMAR		1								
PANAMA		2								
PERU					3			3		
SYRIA					1					
U ARAB EMIRATES		1								
UZBEKISTAN		10	3	3						1
VATICAN			1							1
VIETNAM			1							
YEMEN						3				
MALAYSIA								1		
OMAN								1		

5 CONCLUSION

This analysis shows that universities and R & D institutions are playing a vital role in the development of the nation. The high productivity of these organizations may be due to the good IT infrastructure facilities, government grants and research projects. TIFR ranks first in order contributing 17.65% of PaI, followed by IUCAA 12.05% of PaI in total research output, IIAP with 11.31% of PaI. The other institutes got less than ten percent of PaI., for h index it is observed that among top ten Indian Institutes IUCAA ranks first with highest h-index 67, followed by TIFR with 58 h-index, IIAP with 39 h-index, RRI and Panjab University with 35 h-index each.

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