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Bibliometric Investigation on Research Productivity in Physics, Chemistry and Mathematics in the Indian Institute of Technology (IIT) Kharagpur during 2001-2020

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Abstract **- The study attempts to initiate a bibliometric investigation on the publication trend of research articles of the Indian Institute of Technology(IIT) Kharagpur, the first of the IITs in India recognized as an Institute of National Importance and continued to play a vital role in extending quality education as well as pioneering innovative research in science and engineering. As per the data extracted from SCOPUS on 10.03.2021, IIT Kharagpur contributed 32892 research publications out of which 14130 research publications found in Physics, Chemistry and Mathematics (PCM) in the form of journal articles (11919) and conference paper (2211). The study intends to measure and analyze quantitatively the research productivity of IIT Kharagpur in basic subjects of science, i.e. Physics, Chemistry and Mathematics (PCM) on the basis of the research articles indexed in SCOPUS during last 20 years (2001-2020) with annual growth rate of publications, citations, h-index, authorship pattern, degree of collaboration and other relevant issues. The study also focused on top 15 most prolific authors in terms of productivity count as well as top most favoured sources of publication.**
Keywords: **Indian Institute of Technology (IIT), SCOPUS, Research Productivity, Citation Analysis, H-index, Authorship Pattern, Degree of Collaboration**

I. INTRODUCTION

The Indian Institutes of Technology (IITs) have been recognized all over the world as centers of excellence in study and research in the fields of science and engineering. The IIT systems was established by the Government of India at Kharagpur and started functioning from 1951 with 18 academic departments and 5 centers of excellence and raised to an "Institution of National Importance" by Parliament by means of the Indian Institute of Technology (Kharagpur) Act of 1956. IIT Kharagpur maintains a unique education system model in India and is regarded as crown jewels for their contribution in teaching and research innovations at par with global standards particularly in science and engineering. The institute continued to initiate new strides towards generation and dissemination of scientific and technological knowledge resulted inclusion of new departments, centers and schools. In 2005, the institute consisted of 19 departments, 6 centers and 5 schools which increased to 19 departments, 12 centers and 12 schools in 2020. As productivity is the vital indicator of efficiency in any production system, the research productivity may be considered as an effective parameter to determine the academic credibility of an institution in terms of measuring the quantitative progress in research publication during a time period with qualitative assessment of research publication as a whole or in specific subject areas.

The basic concept in bibliometrics may be defined as output and impact, as measured through publications and citations. The study attempts to provide a scholarly landscape which intends to measure and analyze quantitatively the research productivity of IIT Kharagpur on the basic subjects of science, i.e. Physics, Chemistry and Mathematics (PCM) in basis of the research articles indexed in SCOPUS during last 20 years (2001-2020) with annual growth rate of publications, citations, h-index, authorship pattern, degree of collaboration and other relevant issues.

II. LITERATURE STUDY

The purpose of literature review is to offer an overview of the articles published on the relevant topic. Though several studies have been conducted on measuring and assessment of research output, analyzing research productivity, bibliometic study, scientometric analysis, and citation impact on IITs and other institutions by different authors from time to time, a few such studies found relevant to the present investigation and deserve mention are as under:

1. A study made by Jeevan and Gupta (2002) assessed and compared the impact of research publications of some of the departments of IIT Kharagpur for the period from 1994-95 to 1996-97 as per scientometric techniques.
2. Wani *et al.*, (2013) attempted to gauge the research output of IIT Delhi for the period from 1964 to 2010 as indexed by SCOPUS and disclosed the average citation counts of the institution with highly cited subject fields.
3. Maharana (2013) analyzed the growth, contribution and impact of research carried out by the researchers at the Orissa University of Agricultural Technology (OUAT), Bhubaneswar based on the publications indexed in SCOPUS during 2008 to 2012.
4. A bibliometric study made by Chaurasia and Chavan (2014) attempted to focus on the growth, contribution and impact of research activity of IIT Delhi during the year 2001 to 2010 covered by Web of Science.

5. Hadimani *et al.,* (2015) conducted bibliometric analysis on research publications of IISER (Indian Institute of Science Education and Research), Thiruvananthapuram, India with the support of Web of Science database for the period from 2008-13.
6. Bid (2016) in his paper analyzed the growth and development of research activity of IIT Kharagpur during 2000 to 2015 as indexed in Scopus.
7. Mandhirasalam (2016) performed a scientometric study on publication output of PSG College of Technology (PSGCT), Coimbatore for the period from 1971 to 2014 based on SCOPUS database.
8. Khanna et al (2017) initiated a scientometric analysis of the research output of Physics and Astronomy of Guru Nanak Dev University during 2006-2015 extracting data from SCOPUS.
9. Patel (2018) conducted a scientometric study to examine the research productivity of NIT, Raiput from 2012 to 2016
10. Mohanty and Jena (2019) conducted a scientometric analysis on the research output of IIT Bombay in the field of engineering during 2006-2016.
11. Mohanty and Jena (2020) evaluated research output of the Department of Civil Engineering, IIT Bombay during 2006-2016.
12. Pradhan *et al.,* (2020) analyzed the research productivity and publication impact of National Institute of Technology, Rourkela.
13. Kumar (2020) initiated a study to find out the progress in the research productivity of Indian Institute of Technology (Indian School of Mines) Dhanbad for the period of twenty years (2000-2019) and revealed the notable rise in research publication during the period of study.
14. Subramanyam (1983) proposed bibliometric methods offer a convenient and non-reactive tool for studying collaboration in research.

III. OBJECTIVES OF THE STUDY

1. To measure the year-wise publication of research articles by Indian Institute of Technology (IIT), Kharagpur in basic science subjects, Physics, Chemistry and Mathematics (PCM) out of the year-wise record of total publications during last 20 years (2001-2020).
2. To review the citation profile of IIT Kharagpur in respect to the publication of research articles in PCM and gauge the citation impact in terms of h-index in 2001-2020.
3. To analyze the authorship pattern of the research articles published in PCM.
4. To identify most prolific authors during the period of study.
5. To ascertain the preferred sources of publication.

IV. METHODOLOGY

The data on organization enhanced publications of IIT Kharagpur for the total time span of 20 years (2001-2020) extracted from SCOPUS database on 10.03.2021 for interpretation using affiliation search - AF-ID ("Indian Institute of Technology Kharagpur" 60004750) AND (LIMIT-TO (PUBYEAR , *2020*) OR LIMIT-TO (PUBYEAR , *2019*) OR LIMIT-TO (PUBYEAR , *2018*) OR LIMIT-TO (PUBYEAR , *2017*) OR LIMIT-TO (PUBYEAR , *2016*) OR LIMIT-TO (PUBYEAR , *2015*) OR LIMIT-TO (PUBYEAR , *2014*) OR LIMIT-TO (PUBYEAR , *2013*) OR LIMIT-TO (PUBYEAR , *2012*) OR LIMIT-TO (PUBYEAR , *2011*) OR LIMIT-TO (PUBYEAR , *2010*) OR LIMIT-TO (PUBYEAR , *2009*) OR LIMIT-TO (PUBYEAR , *2008*) OR LIMIT-TO (PUBYEAR , *2007*) OR LIMIT-TO (PUBYEAR , *2006*) OR LIMIT-TO (PUBYEAR , *2005*) OR LIMIT-TO (PUBYEAR , *2004*) OR LIMIT-TO (PUBYEAR , *2003*) OR LIMIT-TO (PUBYEAR , *2002*) OR LIMIT-TO (PUBYEAR , *2001*)) AND (LIMIT-TO (DOCTYPE , *"ar"*) OR LIMIT-TO (DOCTYPE , *"cp"*)) AND (LIMIT-TO (SUBJAREA , *"PHYS"*) OR LIMIT-TO (SUBJAREA , *"CHEM"*) OR LIMIT-TO (SUBJAREA , *"MATH"*)) Subsequently MS-Excel used for the analysis of data.

V. DATA ANALYSIS AND INTERPRETATION

A. Publication Details

According to the data retrieved from SCOPUS, IIT Kharagpur published 32892 research articles during last 20 completed years (2001-2020) in which 14130 articles from the subject areas pf Physics, Chemistry and Mathematics (PCM). Table 1 presented the total number of research articles published by IIT Kharagpur in different years during the total time span of study with share of the PCM publications and percentage. Fig.1 mapped the year wise trend of PCM publication out of the total publication of research article publication of IIT Kharagpur. As per the data presented in the following table that the total publication of research articles in PCM covered more than 40% (42.96%) of the research articles published in total by IIT Kharagpur during last 20 years but the year wise study highlighted that PCM publication covered more than 50% (52.07%) in 2001. The share of PCM publication out of the total research article publication of the institution under study varied between 40-50% during 2002-2018 which became slightly less than 40% in 2019 and 2020.

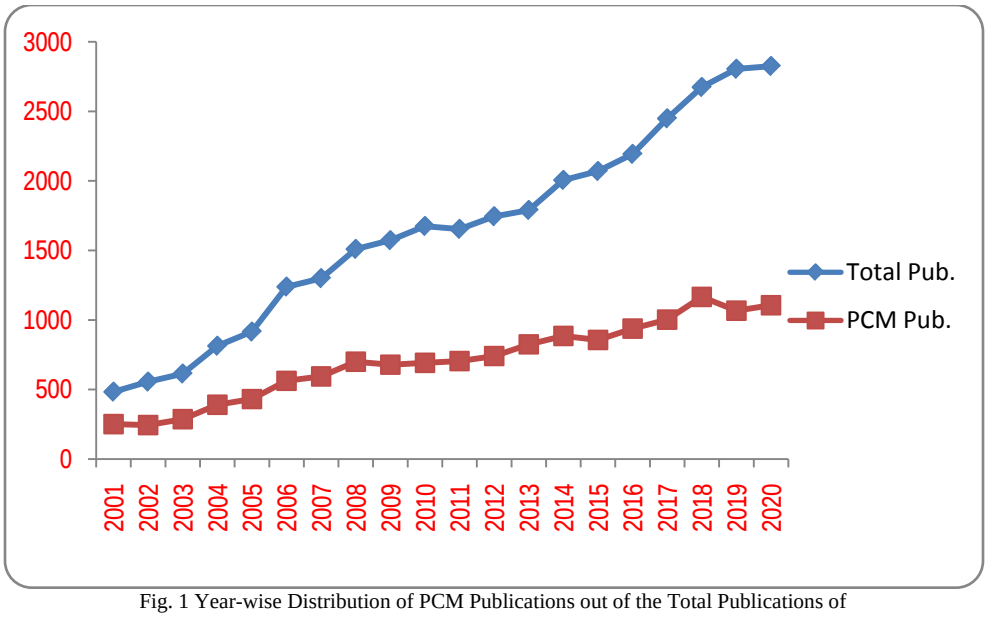

Fig. 1 Year-wise Distribution of PCM Publications out of the Total Publications of IIT Kharagpur during last 20 years (2001-2020)

TABLE I YEAR-WISE DISTRIBUTION OF PCM PUBLICATIONS OUT OF THE TOTAL PUBLICATIONS

Year	Total Publications	Number of Publications in PCM	Percentage (%)
2001	484	252	52.07
2002	556	245	44.06
2003	614	288	46.90
2004	814	391	48.03
2005	916	432	47.16
2006	1239	563	45.44
2007	1300	595	45.77
2008	1510	700	46.36
2009	1573	679	43.17
2010	1675	692	41.31
2011	1654	705	42.62
2012	1745	741	42.46
2013	1790	825	46.09
2014	2006	885	44.12
2015	2070	857	41.40
2016	2193	938	42.77
2017	2449	1003	40.96
2018	2674	1166	43.61
2019	2805	1067	38.04
2020	2825	1106	39.15
2001-2020	32892	14130	42.96

Though the total publications IIT Kharagpur hiked during last 20 years with the increase in the number of departments, centers and schools as well as increase in the number of research publications of each and every units but PCM continued to maintain a progressive trend in research publication except a few years.

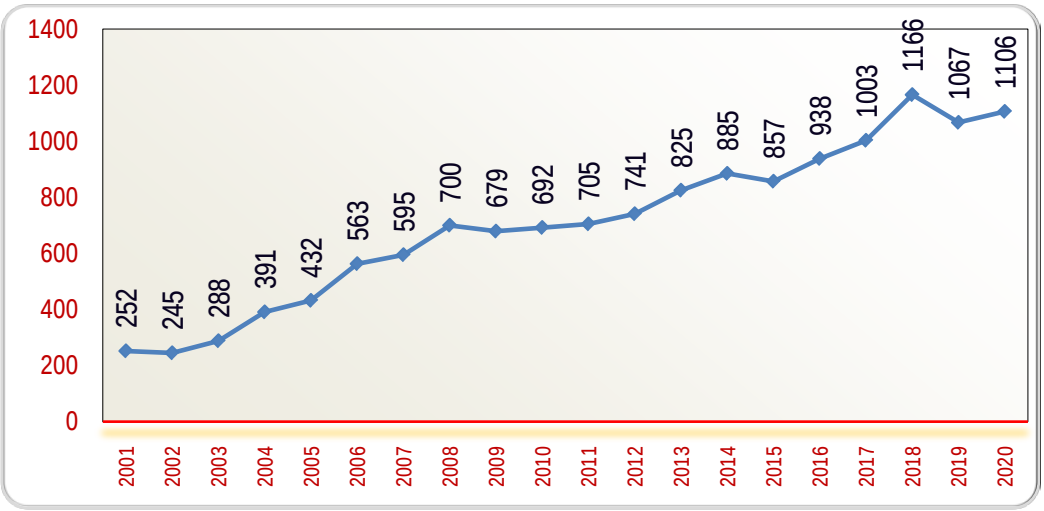

Fig. 2 Publication Trend of PCM Publications IIT Kharagpur during 2001-2020

B. Publication Trend of PCM Articles

Table II presented the total publication count of 14130 research articles in PCM during last 20 years starting from 252 in 2001 to 1106 in 2020.

The maximum number of 1166 articles published in 2018 covered 8.25% of the total publications in PCM followed by 1106 (7.82%) and 1067 (7.55%) in the years 2020 and 2019 respectively. The average annual growth rate found 8.19% in 20 years starting from 2001 to 2020.

TABLE II PUBLICATION TREND OF PCM ARTICLES WITH ANNUAL GROWTH RATE (2001-2020)

Year	Number of Publications in PCM	% of Total Articles Published in 20 Yrs.	Annual Growth Rate (%)
2001	252	1.78	0
2002	245	1.73	-2.77
2003	288	2.04	17.55
2004	391	2.78	35.76
2005	432	3.06	10.48
2006	563	3.98	30.32
2007	595	4.21	5.68
2008	700	4.95	17.64
2009	679	4.80	-3.00
2010	692	4.90	1.91
2011	705	4.99	1.88
2012	741	5.24	5.11
2013	825	5.85	11.34
2014	885	6.26	7.27
2015	857	6.06	-3.16
2016	938	6.65	9.45
2017	1003	7.10	6.93
2018	1166	8.25	16.25
2019	1067	7.55	-8.49
2020	1106	7.82	3.66
2001-2020	14130	100	Average 8.19

C. Citation Profile of IIT Kharagpur in PCM

The citation profile of IIT Kharagpur in PCM during the total time span of 20 years are represented in Table 3 as well as plotted citations and h-index in Fig 3 and Fig 4 respectively. The citations-based values in different years from 2001 to 2020 as derived from SCOPUS are presented in the following table (Table 3). Ranking of the research performance of IIT Kharagpur in PCM on the basis of the derived h-index, the combination of quantity and quality of research publications, reported in the table.

TABLE III CITATION PROFILE OF IIT KHARAGPUR IN PCM (2001-2020)

Year	TP	TC	CA	ACPA	h-index	
					Value	Ranking
2001	252	9225	8650	36.61	46	11
2002	245	7932	7630	32.37	42	13
2003	288	9966	9245	34.60	49	9
2004	391	11670	10736	29.85	54	8
2005	432	12257	11298	28.37	57	6
2006	563	16705	15424	29.67	69	1
2007	595	18128	16558	30.47	64	2
2008	700	18717	17407	26.74	62	3
2009	679	18367	16256	27.05	61	4
2010	692	16293	15122	23.54	58	5
2011	705	12514	11587	17.75	48	10
2012	741	14874	13641	20.07	54	8
2013	825	15541	14174	18.84	55	7
2014	885	13826	12591	15.62	48	10
2015	857	11347	10415	13.24	43	12
2016	938	11270	10290	12.01	41	14
2017	1003	10150	9125	10.12	38	15
2018	1166	9011	8036	7.73	33	16
2019	1067	4602	4166	4.31	22	17
2020	1106	1398	1269	1.26	11	18

TP: Total Publication of PCM Articles; TC : Total Citations; CA : Citing Articles; ACP Average Citation Per Article;

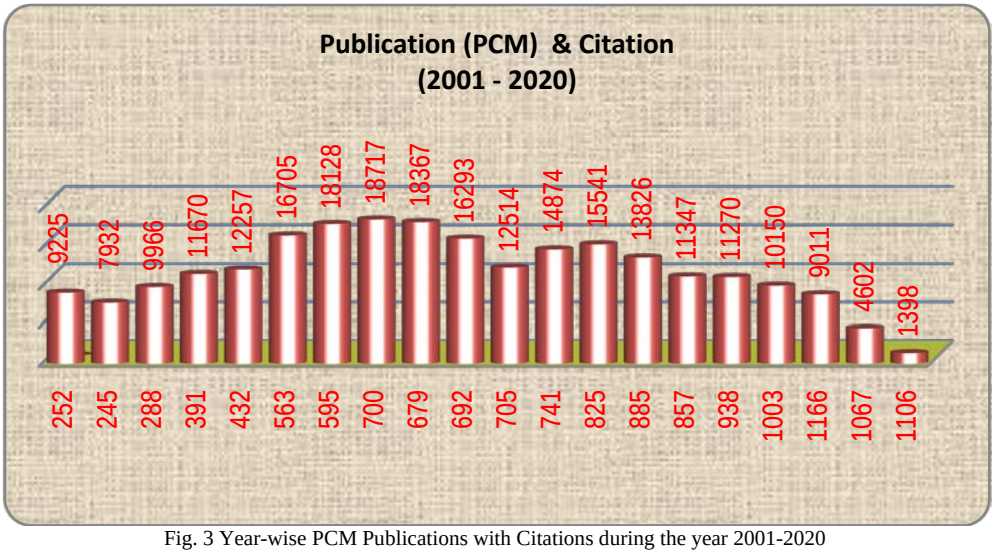

Fig. 3 Year-wise PCM Publications with Citations during the year 2001-2020

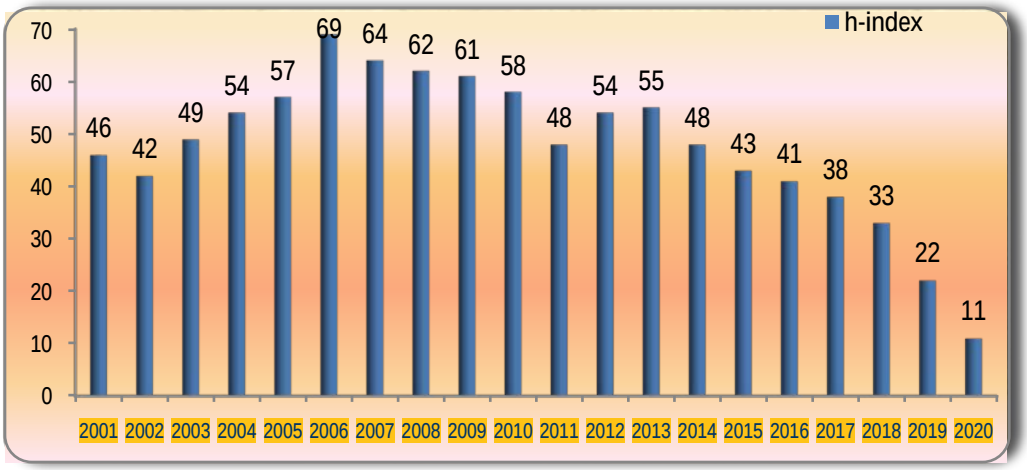

Fig. 4 H-index value of IIT Kharagpur during 2001-2020 in PCM

Table III and Fig 4 witnessed the highest h-index ranking value of IIT Kharagpur in PCM research productivity in the year 2006 with second to fifth ranking in next four consecutive years from 2007 to 2010.

D. Authorship Pattern

Table IV and Fig. 5 projected the authorship pattern of research article publications in PCM by IIT Kharagpur during 2001-2020 indicated that out of 14130 publications majority research articles published in a collaborative way, i.e. Multi-authored articles 13762 (97.40%) and the single authorship contribution counted only 368 (2.60%).

As entered in the table and highlighted in the figure, the highest publications appeared with three authors (4111 – 29.09% of total PCM publications) followed by two authors (4025 – 28.48%) and four authors (2492 –17.63%). Articles with ten authors and above ten found 71 (0.50%) and 142 (1%) numbers respectively.

TABLE IV AUTHORSHIP PATTER OF PCM PUBLICATIONS DURING 2001-2020

Year	One	Two	Three	Four	Five	Six	Seven	Eight	Nine	Ten	>Ten	Total	
2001	18	87	74	40	19	9	2	3	0	0	0	252	1.78
2002	16	77	64	46	34	7	1	0	0	0	0	245	1.73
2003	9	95	80	53	32	10	4	2	3	0	0	288	2.04
2004	20	113	113	76	36	14	7	5	4	1	2	389	2.78
2005	12	124	160	75	33	10	8	6	0	0	4	428	3.06
2006	17	180	169	102	37	26	13	5	4	2	8	555	3.98
2007	25	177	200	106	42	18	15	8	4	0	0	595	4.21
2008	19	209	227	130	65	25	15	4	1	3	2	698	4.95
2009	21	205	220	109	53	30	12	16	8	1	4	675	4.80
2010	25	214	201	113	60	33	21	9	7	2	7	685	4.90
2011	20	218	215	114	67	34	11	12	7	2	5	700	4.99
2012	18	204	205	134	85	28	29	12	7	4	15	726	5.24
2013	9	251	217	161	75	51	20	12	14	4	11	814	5.85
2014	21	256	240	146	86	60	42	8	12	4	10	875	6.26
2015	16	249	225	162	97	47	28	17	6	2	8	849	6.06
2016	22	251	262	151	87	68	47	18	12	9	11	927	6.65
2017	16	268	311	169	102	68	32	13	11	5	8	995	7.10
2018	21	308	340	208	117	71	42	25	12	8	14	1152	8.25
2019	21	272	312	171	137	68	30	18	10	12	16	1051	7.55
2020	22	267	276	226	125	68	45	21	27	12	17	1089	7.82
Grand Total	368 (2.60)	4025 (28.48)	4111 (29.09)	2492 (17.63)	1389 (9.83)	745 (5.27)	424 (3.00)	214 (1.51)	149 (1.05)	71 (0.50)	142 (1.00)	14130	100

The figures in parenthesis indicate the percentage

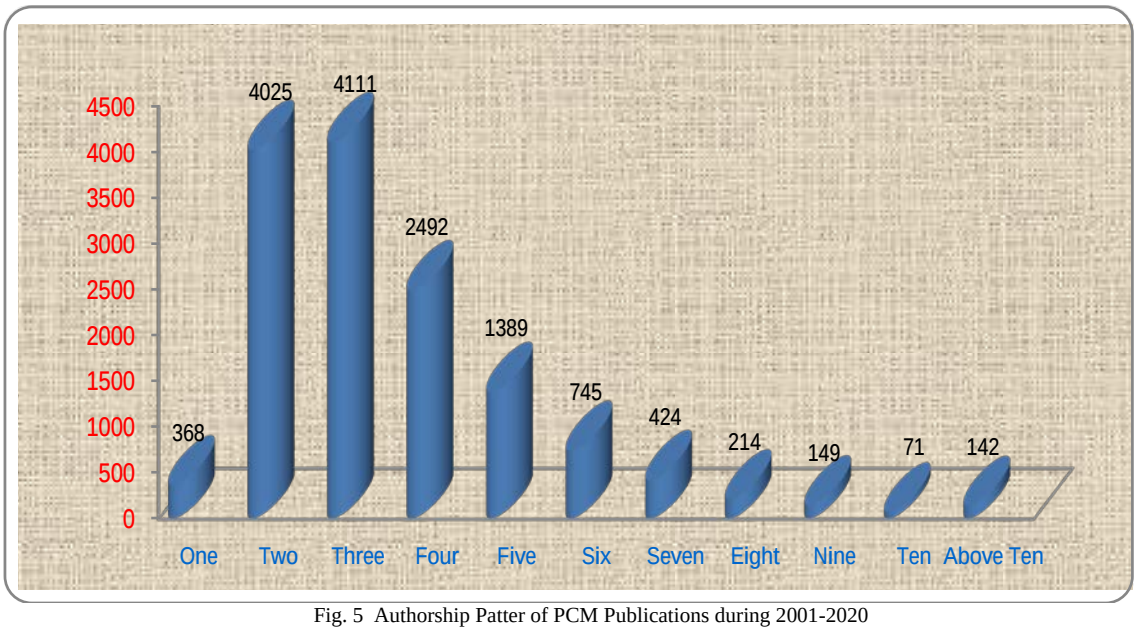

Fig. 5 Authorship Patter of PCM Publications during 2001-2020

E. Degree of Collaboration

Collaboration in research can be considered very essential to trigger the growth of publication. The authorship collaboration of IIT Kharagpur in PCM research publications during the period of study measured with the following formula suggested by Subramanyam (1982):

$$DC = N_M / N_M + N_S$$

Where

DC = Degree of Collaboration

N_S = Number of Single Authors

N_M = Number of Multiple Authors

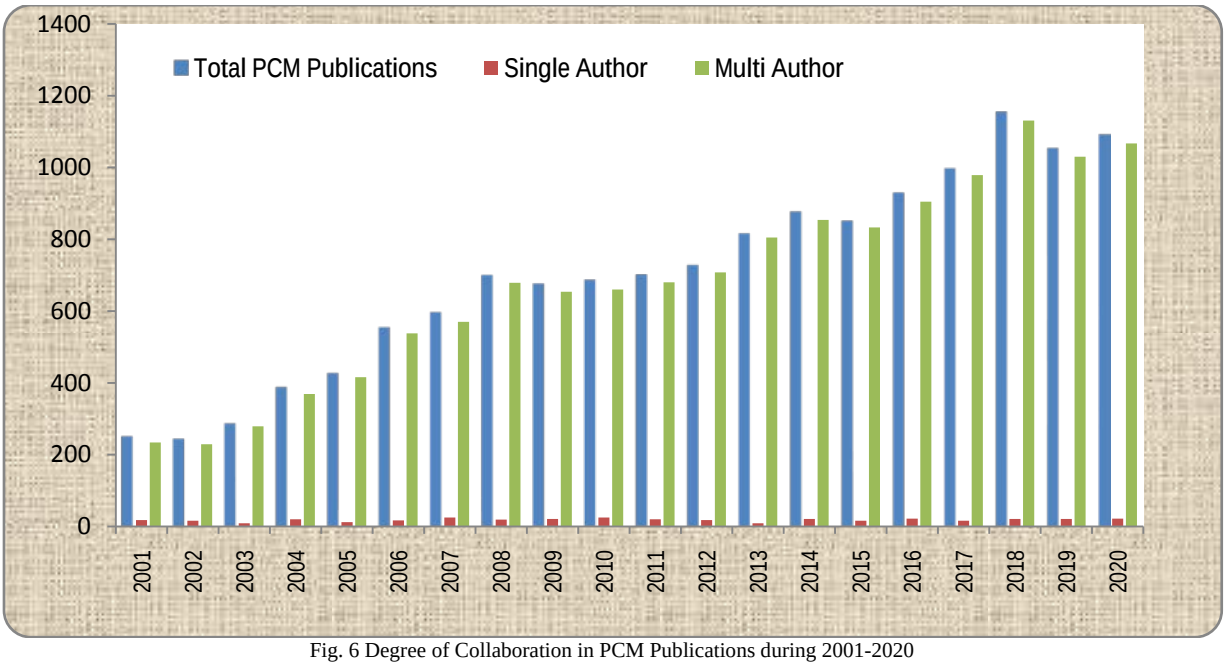

Fig. 6 Degree of Collaboration in PCM Publications during 2001-2020

Table V revealed the number of collaborative research articles to the total number of research articles of PCM publications during period of 20 years (2001-2020) with display in Fig 6, the degree of collaboration varied from 0.93 to 0.99. In different years with an average (mean) collaboration of 0.97. The highest degree of collaboration found 0.99 in the year 2013 and lowest 0.93 in two consecutive years 2001 and 2002.

TABLE V DEGREE OF COLLABORATION IN PCM PUBLICATIONS

Year	Articles of Single Author (N_S)	Articles of Multiple Authors (N_M)	Total ($N_S + N_M$)	Degree of Collaboration (DC)
2001	18	234	252	0.93
2002	16	229	245	0.93
2003	9	279	288	0.97
2004	20	369	389	0.95
2005	12	416	428	0.97
2006	17	538	555	0.97
2007	25	570	595	0.96
2008	19	679	698	0.97
2009	21	654	675	0.97
2010	25	660	685	0.96
2011	20	680	700	0.97
2012	18	708	726	0.97
2013	9	805	814	0.99
2014	21	854	875	0.98
2015	16	833	849	0.98
2016	22	905	927	0.98
2017	16	979	995	0.98
2018	21	1131	1152	0.98
2019	21	1030	1051	0.98
2020	22	1067	1089	0.98
Total	368	13762	14130	0.97

F. Most Preferred Sources of Publication

Table VI indicated as reflected in Fig 7, 15 top sources, where the authors of IIT Kharagpur preferred to publish the research articles in PCM during the period of study. Highest number of 576 articles published in "Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)" followed by 2nd highest of 291 articles published in "Journal of Applied Polymer Science". "RSC Advances" holding 3rd rank with 220 publications.

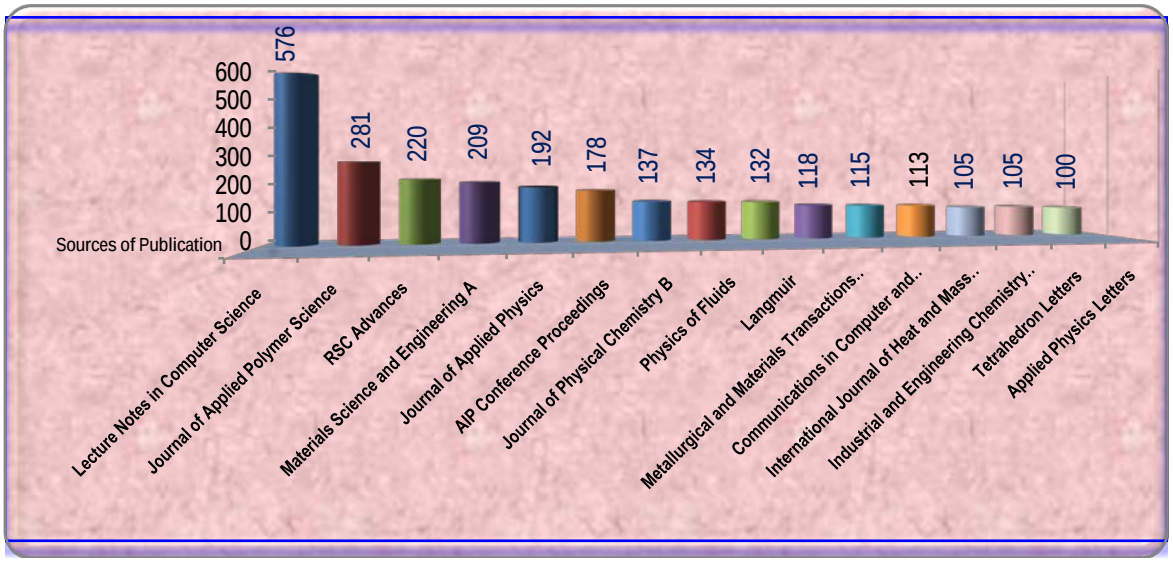

Fig. 7 Preferred Sources of Publication

TABLE VI MOST PREFERRED SOURCES OF PCM PUBLICATIONS

Sl. No.	Source Title	Number of Publications	Rank
1	Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	576	1
2	Journal of Applied Polymer Science	291	2
3	RSC Advances	220	3
4	Materials Science and Engineering A	209	4
5	Journal of Applied Physics	192	5
6	AIP Conference Proceedings	178	6
7	Journal of Physical Chemistry B	137	7
8	Physics of Fluids	134	8
9	Langmuir	132	9
10	Metallurgical and Materials Transactions A: Physical Metallurgy and Materials Science	118	10
11	Communications in Computer and Information Science	115	11
12	International Journal of Heat and Mass Transfer	113	12
13	Industrial and Engineering Chemistry Research	105	13
14	Tetrahedron Letters	105	13
15	Applied Physics Letters	100	14

G. Most Prolific Authors

Table VII and Fig. 8 presented the list of top 15 prolific authors in terms of productivity counting in PCM during 2001-2020. Prof. S. Chakraborty achieved first rank with 376 publications found 2.66 % of the total publications (TP – 14130) during the period of study. Prof. P.K. Chattaraj ranked 2nd with publication of 269 articles followed by Prof. S.K. Ray with 223 articles and ranked 3rd in the publication trend of last 20 years (2001-2020).

TABLE VII MOST PROLIFIC AUTHORS OF PCM PUBLICATIONS

Sl. No.	Authors	Number of publications (* TP - 14130)		Rank
1	Chakraborty, S.	376	2.66 %	1
2	Chattaraj, P.K.	269	1.90 %	2
3	Ray, S. K.	223	1.58 %	3
4	Bhawmick, A. K.	220	1.55 %	4
5	Choudhury, R. N. P.	201	1.42 %	5
6	Pal, T.	192	1.36 %	6
7	Sarkar, N.	170	1.20 %	7
8	Nath, T. K.	154	1.09 %	8
9	De, S.	150	1.06 %	9
10	Manna, I.	148	1.04 %	10
11	Ram, S.	141	0.99 %	11
12	Banerjee, S.	139	0.98 %	12
13	Maiti, T. K.	130	0.92 %	13
14	Singha, N. K.	118	0.83 %	14
15	Basak, A.	113	0.79 %	15

*TP : Total Published Articles during 2001-2020

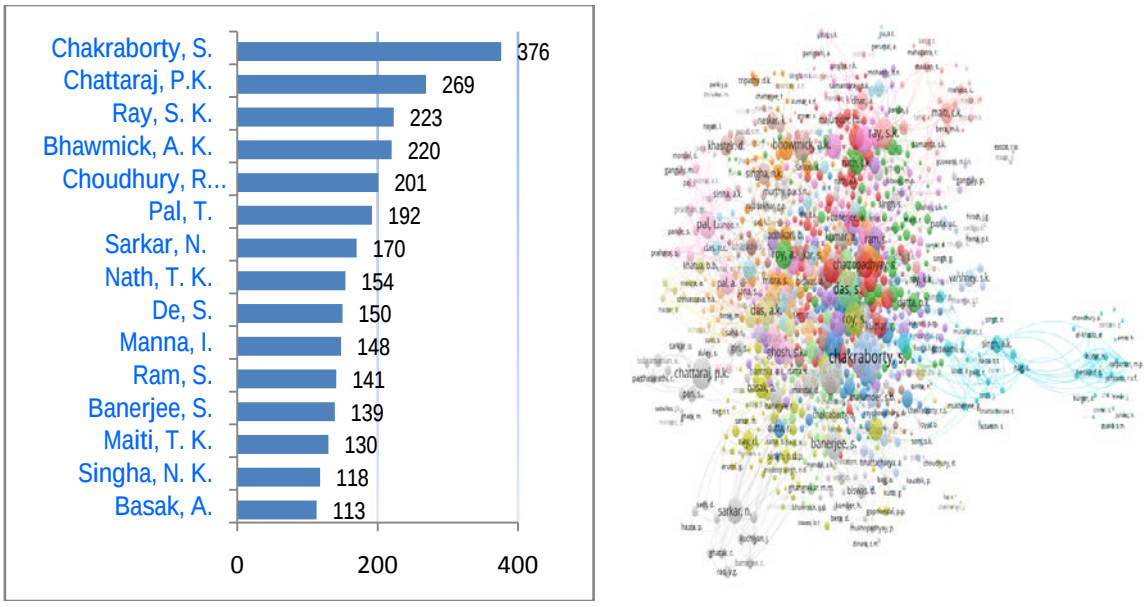

Fig. 8 Most Prolific Authors of PCM Publications

VI. RESEARCH FINDINGS

1. As per the data retrieved from SCOPUS, IIT Kharagpur published 14130 articles in PCM (Physics, Chemistry and Mathematics) out of 32892 research articles published totally during last 20 years (2001-2020) in journals and conference proceedings. The study revealed that the publication of research articles in PCM covered 42.96% of the research articles published in total by IIT Kharagpur but the year wise study highlighted that PCM publication covered 52.07% in 2001, 40-50% during 2002-2018 which became slightly less than 40% in 2019 and 2020. Though increased trend noticed in the number of PCM publications in most of the years but due to addition of new departments/centers/schools in IIT Kharagpur from time to time, the number of total research publications increased in total resulted decrease in the percentage of PCM publications in respect to yearly publications of the institute.
2. Out of the research articles publication counts in PCM during the period of study, the maximum number of 1166 articles published in 2018 covered 8.25% of the total publications in PCM followed by 1106 (7.82%) and 1067 (7.55%) in the years 2020 and 2019 respectively. The average annual growth rate found 8.19% in 20 years starting from 2001 to 2020.
3. The highest h-index ranking value of IIT Kharagpur in PCM research productivity in the year 2006 with second to fifth ranking in next four consecutive years from 2007 to 2010 during the span of 20 years (2001-2020).
4. The authorship pattern of research article publications in PCM by IIT Kharagpur during 2001-2020 indicated that out of 14130 publications majority research articles published in a collaborative way, i.e. Multi-authored articles 13762 (97.40%) and the single authorship contribution counted only 368 (2.60%). The highest publications appeared with three authors (4111 – 29.09% of total PCM publications) followed by two authors (4025 – 28.48%) and four authors (2492 – 17.63%). Articles with ten authors and above ten found 71 (0.50%) and 142 (1%) numbers respectively found minimum.
5. Out of the number of collaborative research articles to the total number of research articles published in PCM during period of 20 years (2001-2020), the degree of collaboration varied from 0.93 to 0.99. in different years with an average (mean) collaboration of 0.97. The highest degree of collaboration found 0.99 in the year 2013 and lowest 0.93 in two consecutive years 2001 and 2002.
6. As per the data derived for the time span of 20 years during 2001-2020 the 15 most preferred source to publish research articles by the authors of IIT Kharagpur in PCM arranged in descending order and ranked. The highest number of 576 articles published in "Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)" followed by 2nd highest of 291 articles published in "Journal of Applied Polymer Science". "RSC Advances" ranked 3rd with 220 publications.
7. In ranking of top 15 prolific authors in terms of productivity counting of IIT Kharagpur in PCM, Prof. S. Chakra borty achieved first rank with 376 publications found 2.66 % of the total publications (TP – 14130) during the period of study. Prof. P.K. Chattaraj ranked 2nd with publication of 269 articles (1.90%) followed by Prof. S.K. Ray with 223 articles (1.58%) and ranked 3rd in the publication trend of last 20 years (2001-2020).

VII. CONCLUSION

IIT Kharagpur being the first premier institution of IIT System in India engaged in providing meaningful education in science and engineering as well as conducting original research of international standard. Though IITs are regarded as the hall marked engineering institutions in India but their academic contributions in the field of science are found very progressive. Basic science subjects like Physics, Chemistry and Mathematics (PCM) considered as important subjects in engineering. The dynamic progress in the research output of IIT Kharagpur in PCM, is evident from the bibliometric investigation based on data retrieved from SCOPUS.

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