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Scientometric Analysis of Indian Chemistry Literature as Reflected in Web of Science Database

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Abstract

The paper analyses the contributions of Indian chemistry literature in publishing research papers as reflected in Thomson Reuters, Web of Science database - Science Citation Index Expanded (SCIE) for the period 1999-2013. The study explores the realm of chemistry research with special reference to Indian researchers who have been resuming unforeseen milestones through pioneering contributions to the field and posing their rank among the universe of scholars across the countries of the globe. Findings of the study reveals: i) the chemistry literature has grown steadily during the period: ii) articles play a predominant source of publication for chemistry literature; iii) the chemistry research of India is fairly collaborative.

Keywords: Scientometric Analysis, Indian Chemistry Literature, Reflected, Web of Science Database.

Introduction

Scientometric is branch of Science. Scientometric explain about input and output resources in term of organizational structure. Scientometric is the Science of measuring and analyzing Science. Modern Scientometric is mostly based on the work of Derek J.de Solla Price and Eugene Garfield[1]. Science and scientific research have been growing at a faster rate during recent years[2]. Chemical sciences epitomize its uniqueness among the different disciplines in science. The progress of research in chemical sciences has been phenomenal leading to emergence of many sub-disciplines such as material science, solid state and surface science, nanoscience and technology, chemical biology and others. Chemistry has justly been called the central science[3]. It deals with the composition, structure and behavior of the atoms and molecules that make up all forms of matter. Chemists study the various substances in the world, with a particular focus on the processes by which one substance is transformed into another. Recently, chemistry is defined as the study of the composition and properties of elements and compounds, the structure of their molecules and the chemical reactions that they undergo[4]. Understanding the world at an atomic level is essential to all areas of science. Chemistry is one of the dynamic disciplines being taught in a large number of Universities in India. Chemistry is further divided into sub branches like Organic, Inorganic, Polymer and Physical chemistry. Research publications are the embodiments of intellectual discoveries primarily aiming to transmit new ideas or information for bringing advancement in knowledge[5].

Chemistry research in India: Research in chemistry has been actively pursued in the country by a number of researchers in universities, research laboratories, other scientific establishments and R and D centers in industries[6]. A few of the top research institutions in India are Indian Institute of Chemical Technology, IISc, Indian Society of Chemists and Biologists, Indian Institutes of Technology, a few universities, etc. The growth of R and D activities in chemical sciences has been spectacular in the last century compared to earlier centuries[7].

Objectives: The specific objectives of the study are to present the growth of literature published by the scientists of chemistry during 1999 to 2013 as per the Web of Science (WoS) database. In particular, the study focuses on the following objectives: i. To study the growth of publications and citations, ii. To study the relative growth rate and doubling time, iii. To study the subject and domain activity indices of chemistry and distribution of articles among sub-disciplines, iv. To study the institutional productivity and international collaborations, v. To study the highly cited papers and the journals preferred by the scientists.

Methodology

The data for this study were collected by searching the Science Citation Index- Expanded (SCI-E) of Web of Science Database which is a very comprehensive and exhaustive database enveloping almost all subjects of Science and Technology. This study uses the database to extract relevant publications data of Indian Chemistry research output for the 15 year period (1999 to 2013). For analysis, Excel and *SPSS 20* are used.

Relative Growth Rate: is the growth rate relative to the size of population. Relative Growth Rate (GR) is the increase in the

number of publications per unit time[8]. The formula for calculating the mean R,

Where: R = mean relative growth rate over the specific period of intervals; W1 = Log W1 (natural log of initial number of publication); W2 = Log W2 (natural log of final number of publication); T2 - T1 = the unit difference between the initial and final time

Doubling Time (Dt): The doubling time is the given period required for quantity to double in size or value. This can be calculated by using the formula.
Doubling time Dt = 0.693/R
Here, Dt (P) = average doubling time of publications

Results and Discussion

Growth of Publications of World and India: Table-1 indicates the chemistry research output of World and India, average citations per papers and global publications share of India. India has produced 46,420 publications, and received 11,14,768 citations during the period 1999-2013, Average Citations per Paper is 11.29. As per the web of science data, cumulative publications growth, the cumulative chemistry publications output of India had increased from 6,406 publications during 1999-2003 to 14,224 publications during 2004-2007, and 25,790 publications during 2008-2013. India's publications are gradually increased year by year. The global publications share of India during 1999-2013 was 4.31 %, which has increased from 2.52 in 1999 to 5.32 in 2013. This analysis proves that there is an increasing trend in the Indian chemistry research.

The global research output in chemistry research has increased from 2,19,070 in 1999 to 5,20,344 in 2013. The trend shows a steady and significant increase in the publications. In the same manner, the Indian research output in chemistry too has increased from 6,406 in 1999 to 25,790 by 2013. The trend shows a higher steepness, indicating a faster increase in research output vis-à-vis global research output (Table 1).

Relative Growth Rate and doubling time: Table-2 reveals total output of world and India has been shown in Table-2 (fifteen year) along with the growth rate and doubling time. The table shows that the relative growth rate of world output decreases gradually from 0.698 to 0.114 in fifteen year's period (1999-2013). The doubling time (Dt) correspondingly increases from 0.993 to 6.079 in this period. The mean growth rate and doubling time for the world is 0.220 and 3.522 respectively.

Indian output, as shown in Table-2, also decreases gradually from 0.703 to 0.143 during fifteen years period (1999-2013). This growth may be due to the establishment of major scientific institutions which resulted into more scientific research. Correspondingly, the doubling time increases from 0.986 to 4.851 in the same period. The mean growth rate and doubling time for Indian output is 0.255 and 2.893.

Table-1
Growth of Publications of World and India in Chemistry

Year	World (TP)	India (TP)	% TP Share	ACPP
1999	39973	1006	2.52	14.01
2000	40360	1026	2.54	16.42
2001	43484	1331	3.06	17.04
2002	45713	1437	3.14	17.22
2003	49540	1606	3.24	16.92
2004	55242	2126	3.85	17.21
2005	58446	2265	3.88	16.61
2006	66936	2681	4.01	15.15
2007	74404	3428	4.61	13.83
2008	83148	3724	4.48	11.81
2009	90062	4458	4.95	10.38
2010	96921	4543	4.69	8.51
2011	107898	5297	4.91	6.52
2012	109357	5312	4.86	4.33
2013	116106	6180	5.32	5.40
1997-2003	219070	6406	2.92	16.41
2004-2008	338176	14224	4.21	14.70
2009-2013	520344	25790	4.96	6.82
1999-2013	**1077590**	**46420**	**4.31**	**11.29**

Note- TP= Total Publications, ACPP= Average Citations per Publications

Table-2
World v/s India Relative Growth Rate (RGR) and Doubling Time (Dt.)

Year	World TP	RGR	Dt.(P)	India TP	RGR	Dt.(P)
1999	39973			1006		
2000	40360	0.698	0.993	1026	0.703	0.986
2001	43484	0.433	1.602	1331	0.504	1.376
2002	45713	0.314	2.205	1437	0.356	1.948
2003	49540	0.256	2.703	1606	0.289	2.401
2004	55242	0.225	3.082	2126	0.287	2.418
2005	58446	0.193	3.588	2265	0.235	2.943
2006	66936	0.183	3.781	2681	0.222	3.125
2007	74404	0.171	4.059	3428	0.227	3.058
2008	83148	0.162	4.289	3724	0.199	3.481
2009	90062	0.150	4.626	4458	0.196	3.542
2010	96921	0.140	4.967	4543	0.166	4.164
2011	107898	0.135	5.119	5297	0.164	4.214
2012	109357	0.121	5.739	5312	0.142	4.895
2013	116106	0.114	6.079	6180	0.143	4.851
Mean Value		**0.220**	**3.522**		**0.255**	**2.893**

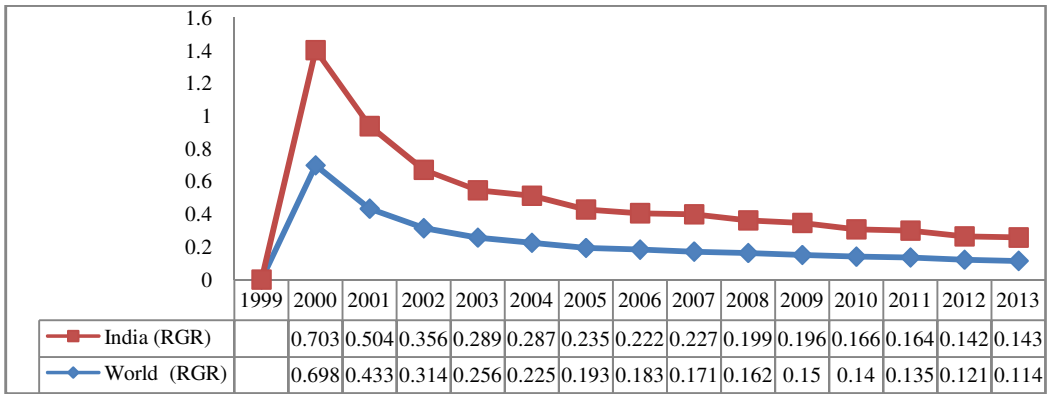

Figure-1
World vs India Relative Growth Rate (RGR)

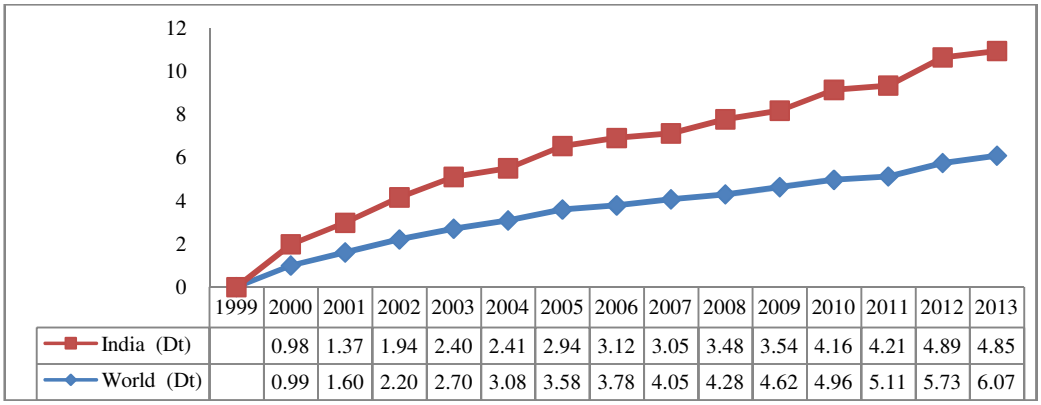

Figure-2
World v/s India Doubling Time (Dt.)

Table 3: World Output Vs. Indian Output: Table-3 data contains total publications of 46420 by Indian scientists in the field of chemistry during the period of study. The total publication output constituted about 4.30 per cent of the world output. Here, activity index (AI) suggested by frame and elaborated by Schubert, and Braun, Garg and Nagpaul, has been used to compare India's research performance. The AI characterizes the relative research effort of a country in a given subject field. Activity index was first proposed by Frame and later elaborated by Schubert and Braun. It characterizes the relative the relative research effort a nation or an institution devotes to a given subject field or sub- field into consideration the effort of the size of the country as well as the size of the sub- specially. Activity Index (AI) characterizes the relative research effort of a country in given subjects. It is defined as follows:

$$AI = \frac{\text{given field's share in the country' s publication output}}{\text{given field's share in the world's s publication output}}$$

AI= 100 indicates that the country's research effort in the given field corresponds precisely to the world's average. AI> 100 reflects higher activity than the world's average, and AI<100 indicates lower activity than the world's average.

Here, AI for India has been calculated for different years analyze how India's performance changed during different years using the above formula. Here AI has been calculated as followed:

$$AI = \frac{\text{India's output in a particular year/ Total Indian output}}{\text{World's output in a particular year/ total world's output}}$$

Mathematically, $AI = \frac{nij/nio}{noj/noo} * 100$

Where: nij : Indian output of papers in particular field, nio: Total Indian output on all subjects, noj: World output of papers in particular field, noo: Total World output on all subjects.

Here: nij, is the Indian output in the year i; njo is the total Indian output; noj is the world output in the year I; and noo is the total world output.

Table 3 presents the results of the AI of India in the field of chemistry different years 1999 (58.42), 2000 (59.01), 2001 (71.06), 2002 (72.97), 2003 (75.26), 2004 (89.34), 2005 (89.96), 2006 (92.98), 2007 (106.95), 2008 (103.97), 2009 (114.91), 2010 (108.81), 2011 (113.96), 2012 (112.76) and 2013 (123.56). The average value of the AI for India during 1999 – 2013 was 92.93 which indicates that India's research effort in chemistry was slightly more when compared to the world average.

Subject – wise distribution of Publications in Chemistry literature: Table 4 reveals various subjects actively engaged in research in the field of chemistry output in highest AI in various subject categories as follows: Materials Science (123.36) in 2001 Physics (115.97 in 2000, Pharmacology Pharmacy (144.21) in 2012, Engineering (130.63) in 1999, Biochemistry Molecular Biology (89.48) in 2012, Science Technology Other Topics (106.63) in 2006, Food Science Technology (113.82) in 1999, Electro Chemistry (153.23) in 2002, Metallurgy Metallurgical Engineering (227.74) in 2001, and Crystallography (315.25) in 1999. It is observed from the data that it indicates India's research efforts in these subjects correspond to the world's average.

Table-3
World and Indian output in chemistry during 1999 – 2013

Year	World (TP)	India (TP)	AI- Index
1999	39973	1006	58.42
2000	40360	1026	59.01
2001	43484	1331	71.06
2002	45713	1437	72.97
2003	49540	1606	75.26
2004	55242	2126	89.34
2005	58446	2265	89.96
2006	66936	2681	92.98
2007	74404	3428	106.95
2008	83148	3724	103.97
2009	90062	4458	114.91
2010	96921	4543	108.81
2011	107898	5297	113.96
2012	109357	5312	112.76
2013	116106	6180	123.56
Average AI	**1077590**	**46420 (4.30)***	**92.93****

Note : * Percentage of World output ** average activity index of India

Research productivity and impact of top 20 most productive Indian research institutes during 1999 -2013 in the field of Chemistry literature: Table-5 depicts the cumulative output of top 20 productive research institutes in chemistry consists of 72,698 publications, with an average of 3,634.9 publications per institute. Eight institutes registered higher number of publications than the group average. They are Council of Scientific Industrial Research (CSIR), Delhi (20,060 publications), Indian Institute of Technology (IIT), Delhi (11,218 publications), Indian Institute of Chemical Technology (IICT), Hyderabad (3,902 publications), Indian Institute of Science (IISC), Bangalore (3,762 publications), National Chemistry Laboratory, Pune (3,344 publications), Indian Association for the Cultivation of Science Kolkata (2,713 publications), Indian Association for the Cultivation of Science (IACS), Jadavapur (2,671 publications).

Table-4
Activity Index for sub-fields of Chemistry

Year	Materials Science	Physics	Pharmacology Pharmacy	Engineering	Biochemistry Molecular Biology	Science Technology Other Topics	Food Science Technology	Electro Chemistry	Metallurgy Metallurgical Engineering	Crystallography
1999	95.25	99.11	82.31	**130.63**	48.34	48.33	**113.82**	146.30	160.94	**315.25**
2000	105.26	**115.97**	94.16	101.23	47.04	65.27	100.12	126.81	161.09	241.86
2001	**123.36**	105.34	99.10	95.57	43.33	75.01	95.45	120.33	**227.74**	198.26
2002	90.94	96.17	130.25	106.90	65.66	87.51	96.73	**153.23**	123.00	223.37
2003	92.41	105.62	133.07	103.61	69.47	56.50	91.04	89.79	147.93	234.24
2004	97.67	101.74	134.06	106.80	69.46	74.59	66.25	149.56	126.64	188.61
2005	93.35	108.76	126.90	86.24	75.94	106.36	89.93	95.62	127.55	207.03
2006	96.62	109.04	99.26	86.03	82.54	**106.63**	84.48	101.02	88.23	295.21
2007	100.39	109.40	102.57	67.52	73.89	104.44	89.93	131.22	139.48	228.60
2008	101.45	103.50	113.42	76.99	74.62	93.99	78.46	126.80	177.64	196.02
2009	106.55	107.89	118.57	79.15	72.26	88.78	66.24	101.04	175.46	144.11
2010	102.55	103.35	132.59	79.64	73.76	74.60	89.45	100.22	226.36	151.27
2011	102.17	108.33	123.45	77.32	83.87	85.20	65.55	111.90	194.15	149.14
2012	97.48	107.38	**144.21**	85.32	**89.48**	77.47	63.44	108.45	186.29	172.12
2013	106.12	110.68	91.16	87.81	80.53	87.28	61.09	96.13	182.23	179.87
Average AI	**100.77**	**106.15**	**115.01**	**91.39**	**70.01**	**82.13**	**83.47**	**117.23**	**162.98**	**208.33**

The total publications published by these 20 research institutes received 6,27,187 citations, with an average of 8.63 citations per publication. Twelve institutes scored higher citations than the group average. These are: Jawaharlal Nehru Center for Advanced Scientific Research, Bangalore, with average citations per publication of 28.87, followed by University of Hyderabad, Hyderabad (19.79), Indian Institute of Science (IISC), Bangalore (19.46), National Chemistry Laboratory, Pune (18.58), Indian Institute of Technology (IIT), Kanpur (17.53), Indian Institute of Chemical Technology (IICT), Hyderabad (16.48), Indian Association For The Cultivation of Science (IACS), Jadavapur (15.9), Indian Association for the Cultivation of Science Kolkata (15.87), Indian Institute of Technology (IIT), Kharagpur (15.73), Indian Institute of Technology (IIT), Bombay (14.56), Indian Institute of Technology (IIT), Roorkee (12.81), Indian Institute of Technology (IIT), Madras (12.49).

The average h-index value of these 20 institutes 58.95. Ten institutes scored higher h-index value than group average. These are Indian Institute of Science (IISC), Bangalore with an h-index of 100, followed by Jawaharlal Nehru Center for Advanced Scientific Research, Bangalore (88), Indian Institute of Chemical Technology (IICT), Hyderabad (86), National Chemistry Laboratory, Pune (86), University of Hyderabad, Hyderabad (74), Indian Institute of Technology (IIT), Kanpur (73), Indian Association for the Cultivation of Science Kolkata (71), Indian Association For The Cultivation of Science (IACS), Jadavapur (71), Indian Institute of Technology (IIT), Kharagpur (70), Jadavapur University, Jadavapur (61) (Table 5)

Impact of Journals of Indian contributions in the Journals 1999-2013: Table-6 shows that top most 20 productive Indian and foreign journals together the impact of journals of Indian contributions in chemistry. Further impact of journals of Indian contributions in chemistry has been given in the impact factor is one of these; it is a measure of the frequency with which the average article in a journal has been cited in a given period of time. The impact factor for a journal in calculated based on a 3 yaers period, and can be the average number of times published publications are cited up to 2 years after publication. Impact factor of the chemistry journals are mentioned in the table-6.

Based on the average citations per publication the Journal of Organic Chemistry holds the first position (23.93), followed by Chemical Communications (22.01), Journal of Physical Chemistry B (21.91), Tetrahedron (19.91) and Journal of Molecular Catalysis A Chemical (19.69).

Table-5
Research productivity and impact of top 20 most productive Indian research institutes during 1999 -2013 in the field of Chemistry literature

Research / Academic Institution	TP	Citations	ACP	H-INDEX
Council of Scientific Industrial Research (CSIR), Delhi	20060	NA	NA	NA
Indian Institute of Technology (IIT), Delhi	11218	NA	NA	NA
Indian Institute of Chemical Technology (IICT), Hyderabad	4829	79603	16.48	86
Bhabha Atomic Research Center (BARC), Mumbai	3902	38488	9.86	59
Indian Institute of Science (IISC), Bangalore	3762	73195	19.46	100
National Chemistry Laboratory, Pune	3344	62116	18.58	86
Indian Association for the Cultivation of Science Kolkata	2713	43054	15.87	71
Indian Association for the Cultivation of Science (IACS), Jadavapur	2671	42470	15.9	71
Indian Institute of Technology (IIT), Bombay	2199	32013	14.56	60
Jadavapur University, Jadavapur	2131	25960	12.18	61
Indian Institute of Technology (IIT), Kanpur	2004	35125	17.53	73
Indian Institute of Technology (IIT), Kharagpur	1964	30889	15.73	70
University of Delhi, Delhi	1829	20281	11.09	54
Indian Institute Of Technology (IIT), Madras	1715	21421	12.49	57
University of Hyderabad, Hyderabad	1690	33444	19.79	74
Banaras Hindu University, Varanasi	1556	14667	9.43	46
Jawaharlal Nehru Center for Advanced Scientific Research, Bengaluru	1362	39323	28.87	88
Indian Institute of Technology (IIT), Roorkee	1318	16887	12.81	51
University Rajasthan, Jaipur Rajastan	1226	7207	5.88	31
University of Calcutta , Kolkata	1205	11044	9.17	41
total	**72698**	**627187**	**8.63**	**58.95**

Note: NA= Not available, TP- Total Publications, TC- Total citations, ACP- Average citation per paper

Publications' output and citations received by publications in India in Chemistry literature: Table-7 reveals the international collaborative publications of India with top with 20 countries during 1999-2013. The share of International publications in the Indian chemistry literature research output was among the different collaborative countries the USA ranked with 3,858 publications and 63,691 citations (16.51 ACP and 88 H-index), followed by Germany which ranked 1,931 publications and 32,855 citations (17.01 ACP and 70 H-index), Japan ranked third with 1,531 publications and 29,011 citations. South Korea 1,284 and England 1,149 publications ranked fourth and fifth respectively.

Table-6
Impact of journals of Indian contributions in the journals 1999-2013

Journal Name	Country	TP	TC	ACP	Impact Factor
Asian Journal of Chemistry	India	5210	4980	0.96	0.36 0
Tetrahedron Letters	London	3803	62678	16.48	2.391
Journal of the Indian Chemical Society	India	2896	6528	2.25	0.251
Indian Journal of Chemistry Section B Organic Chemistry Including Medicinal Chemistry	India	2689	10316	3.84	0.489
Indian Journal of Chemistry Section A Inorganic Bio Inorganic Physical Theoretical Analytical Chemistry	India	2128	8742	4.11	0.628
Journal of Alloys and Compounds	Netherlands	1816	16350	9	2.726
Synthetic Communications	London	1687	11787	6.99	0.984
Indian Journal of Heterocyclic Chemistry	India	1517	3108	2.05	0.170
Journal of Physical Chemistry B	USA	1387	30384	21.91	3.377
Tetrahedron	Netherlands	1299	25871	19.92	2.817
Abstracts of Papers of the American Chemical Society	USA	1187	1	0	11.444
Chemical Physics Letters	Netherlands	1092	15298	14.01	1.991
Bioorganic Medicinal Chemistry Letters	Netherlands	1058	14791	13.98	2.331
Polyhedron	Netherlands	1046	13916	13.3	2.047
Indian Journal of Chemical Technology	India	1040	2731	2.63	0.580
Applied Surface Science	Netherlands	1027	10818	10.53	2.538
Journal of Molecular Catalysis A Chemical	Netherlands	1010	19885	19.69	3.679
Journal of Organic Chemistry	USA	946	22635	23.93	4.638
Journal of Nanoscience and Nanotechnology	USA	939	5250	5.59	1.339
Chemical Communications	London	924	20341	22.01	6.718

Research patterns of high cited papers: Table-10 shows characteristics of selected highly cited papers of India in chemistry were also evaluated in this section and the list of such high – cited papers is presented based on publication output of India in this area, 20 papers are identified as highly cited ones, who have received citations from 568 to 1,509 during 1999 to 2013 of these 20 papers,

Table-7
Publications' output and citations received by publications in India in Chemistry literature

Country	Total Publication (TP)	Total Citations (TC)	Average Citations per Publication (ACP)	H-Index
USA	3858	63691	16.51	88
Germany	1931	32855	17.01	70
Japan	1531	29011	18.95	70
South Korea	1284	13336	10.39	45
England	1149	17948	15.62	53
France	1110	18185	16.38	59
Spain	809	14637	18.09	53
Italy	732	11187	15.28	48
Taiwan	639	9307	14.56	47
Canada	568	7545	13.28	41
Saudi Arabia	442	3581	8.1	28
Australia	381	4640	12.18	33
Peoples R China	360	6137	17.05	41
Malaysia	347	2566	7.39	23
Switzerland	300	4759	15.86	32
Portugal	232	2618	11.28	25
Singapore	220	3364	15.29	31
Belgium	219	3163	14.44	30
Czech Republic	218	3262	14.96	31
South Africa	204	1684	8.25	21

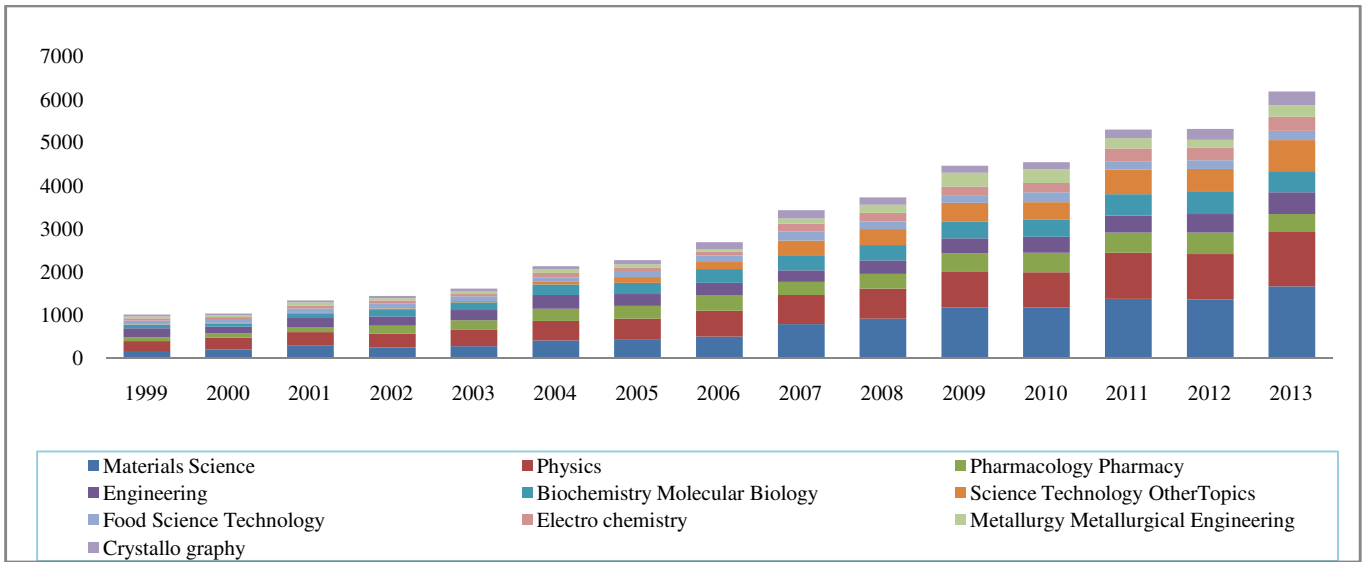

Figure-3
Subject wise Productivity in India

Table-8
Subject wise productivity in India

Year	Materials Science	Physics	Pharmacology Pharmacy	Engineering	Biochemistry Molecular Biology	Science Technology Other Topics	Food Science Technology	Electro Chemistry	Metallurgy Metallurgical Engineering	Crystallo Graphy	Total
1999	159	226	87	211	82	9	89	50	45	48	1006
2000	194	276	95	155	75	15	86	46	50	34	1026
2001	291	300	126	202	96	29	97	60	84	46	1331
2002	239	315	189	219	148	37	114	67	51	58	1437
2003	271	373	222	242	181	30	111	51	54	71	1606
2004	399	455	285	315	246	61	99	107	83	76	2126
2005	416	491	297	272	263	130	147	78	74	97	2265
2006	490	601	362	288	319	162	150	88	57	164	2681
2007	779	675	305	271	331	358	209	185	123	192	3428
2008	903	700	346	313	350	376	177	202	188	169	3724
2009	1168	826	425	354	393	432	175	204	321	160	4458
2010	1166	818	452	371	394	407	235	216	320	164	4543
2011	1366	1074	466	393	499	570	194	301	238	196	5297
2012	1350	1056	501	431	510	540	194	299	176	255	5312
2013	1657	1281	399	508	487	721	212	331	265	319	6180
Total	10848	9467	4557	4545	4374	3877	2289	2285	2129	2049	46420

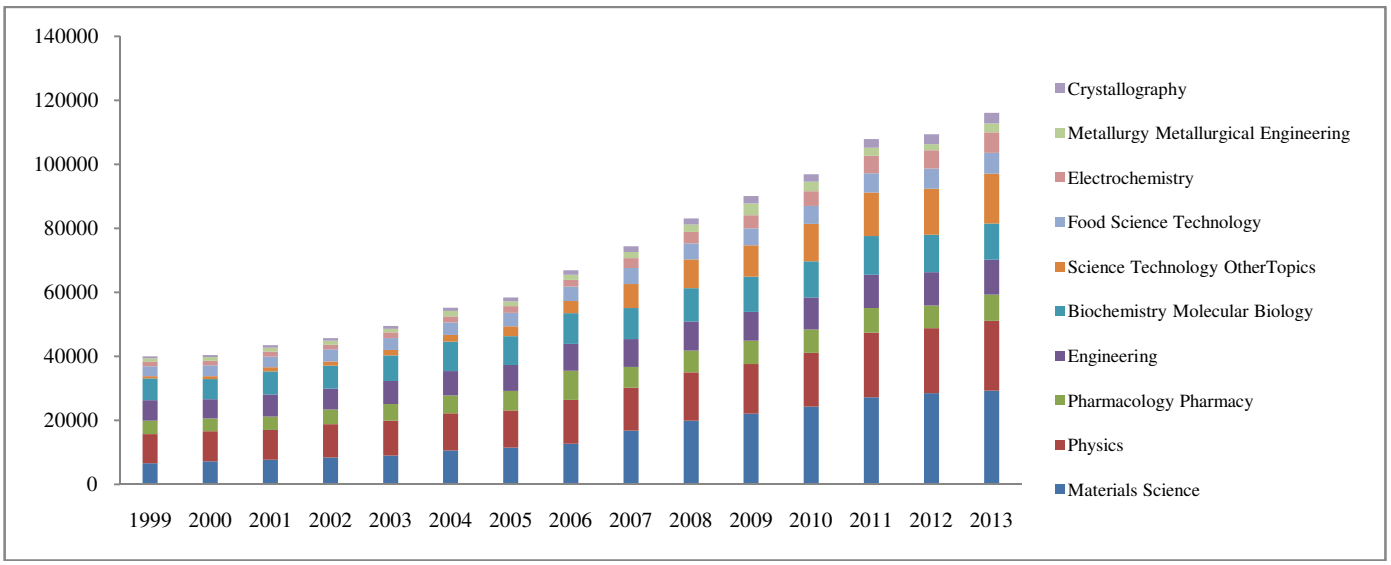

Figure-4

Subject wise Productivity in World
Table-9
Subject wise productivity in World

Year	Materials Science	Physics	Pharmacology Pharmacy	Engineering	Biochemistry Molecular Biology	Science Technology other Topics	Food Science Technology	Electro Chemistry	Metallurgy Metallurgical Engineering	Crystallo Graphy	Total
1999	6633	9061	4200	6418	6740	740	3107	1358	1111	605	39973
2000	7250	9362	3969	6023	6272	904	3379	1427	1221	553	40360
2001	7707	9304	4154	6905	7239	1263	3320	1629	1205	758	43484
2002	8360	10420	4616	6517	7170	1345	3749	1391	1319	826	45713
2003	9046	10894	5146	7205	8037	1638	3761	1752	1126	935	49540
2004	10615	11620	5524	7664	9202	2125	3883	1859	1703	1047	55242
2005	11499	11649	6039	8139	8937	3154	4218	2105	1497	1209	58446
2006	12662	13761	9105	8358	9649	3793	4433	2175	1613	1387	66936
2007	16843	13392	6454	8711	9723	7440	5044	3060	1914	1823	74404
2008	19873	15101	6811	9077	10472	8932	5037	3557	2363	1925	83148
2009	22146	15467	7241	9035	10988	9830	5337	4079	3696	2243	90062
2010	24256	16886	7273	9938	11396	11640	5605	4598	3016	2313	96921
2011	27234	20194	7689	10353	12119	13627	6029	5479	2497	2677	107898
2012	28511	20246	7152	10399	11733	14350	6295	5676	1945	3050	109357
2013	29335	21745	8223	10869	11361	15520	6520	6469	2732	3332	116106
Total	241970	209102	93596	125611	141038	96301	69717	46614	28958	24683	1077590

Conclusion

The paper presents a sense of the importance of Indian chemistry research, and as such informs that community, as well as researchers involved in citation analysis. The situation demands for an effective means of measurement of the growth of scientific literature, recognition of scientists who have major impact in their discipline, recognition of core journals in the discipline and identification of trends in the discipline etc. for framing effective library policies by the professionals. Results of such studies also help the policy makers to decide priorities in resource allocation for scientific activities. At present, bibliometrics has established itself as a viable and distinctive research technique for studying the science of science based on bibliographical and citation data.

The outcome of the study is an original research work with citation analysis of top research papers in chemistry. The findings will have practical implications for Indian scientists, funding agencies and research establishments in different areas of chemical sciences. The analysis of literature in chemistry contributed by researchers of India brings to light some interesting facts about the literature as well as the authors. The pattern of year-wise output is in upward position from year to year. The nature of collaboration trend among faculties is at

international and national levels. It indicates the faculties' upward sight for collaboration.

Table-10
List of top 20 highly cited papers, 1999-2013

No. of Citations received	Tittle of the paper	Authors	Source	Year of publication
1509	Metal carboxylates with open architectures	Rao, CNR; Natarajan, S; Vaidhyanathan, R	Angewandte Chemie-International	2004
1264	Recent advances in the Baylis-Hillman reaction and applications	Basavaiah, D; Rao, AJ; Satyanarayana, T	Chemical Reviews	2003
1229	Graphene: The New Two-Dimensional Nanomaterial	Rao, C. N. R.; Sood, A. K.; Subrahmanyam, K. S.; et al.	Angewandte Chemie-International	2009
1206	Hydrogen bridges in crystal engineering: Interactions without borders	Desiraju, GR	Accounts Of Chemical Research	2002
1104	Biodegradable polymeric nanoparticles as drug delivery devices	Soppimath, KS; Aminabhavi, TM; Kulkarni, AR; et al	Journal of Controlled Release	2001
1099	Recent applications of the Suzuki-Miyaura cross-coupling reaction in organic synthesis	Kotha, S; Lahiri, K; Kashinath, D	Tetrahedron	2002
1064	A review of chitin and chitosan applications	Kumar, MNVR	Reactive and Functional Polymers	2000
901	Chitosan chemistry and pharmaceutical perspectives	Kumar, MNVR; Muzzarelli, RAA; Muzzarelli, C; et al.	Chemical Reviews	2004
848	Controlling the aspect ratio of inorganic nanorods and nanowires	Murphy, CJ; Jana, NR	Advanced Materials	2002
835	Supramolecular gels: Functions and uses	Sangeetha, NM; Maitra, U	Chemical Society Reviews	2005
803	Hydrogen production by biological processes: a survey of literature	Das, D; Veziroglu, TN	International Journal Of Hydrogen Energy	2001
711	Recent developments in ring opening polymerization of lactones for biomedical applications	Albertsson, AC; Varma, IK	Biomacromolecules	2003
698	Recent advances on chitosan-based micro- and nanoparticles in drug delivery	Agnihotri, SA; Mallikarjuna, NN; Aminabhavi, TM	Journal of Controlled Release	2004
692	Cyanines during the 1990s: A review	Mishra, A; Behera, RK; Behera, PK; et al.	Chemical Reviews	2000
688	Conducting polymer nanocomposites: A brief overview	Gangopadhyay, R; De, A	Chemistry of Materials	2000
681	Interparticle coupling effect on the surface plasmon resonance of gold nanoparticles: From theory to applications	Ghosh, Sujit Kumar; Pal, Tarasankar	Chemical Reviews	2007
638	Application of conducting polymers to biosensors	Gerard, M; Chaubey, A; Malhotra, BD	Biosensors and Bioelectronics	2002
608	Biological synthesis of triangular gold nanoprisms	Shankar, SS; Rai, A; Ankamwar, B; et al.	Nature Materials	2004
570	Kinetics and mechanism of removal of methylene blue by adsorption on various carbons - a comparative study	Kannan, N; Sundaram, MM	Dyes and Pigments	2001
568	Inorganic nanowires	Rao, CNR; Deepak, FL; Gundiah, G; et al.	Progress in Solid State Chemistry	2003

References

1. http://digitalcommons.unl.edu/ (2015)

2. Bala M. and Singh M.P. (2014). A Scientometric study of journal of bio-chemistry and biophysics (IJBB). *Library Philosophy and Practice* (e-journal). http:// digitalcommons.unl.edu/libphilprac/1168.

3. Maharana B., Majhi S. and Sethi B.B. (2011). Citation analysis of top research papers in chemistry with specific reference to India. *Library Review,* 60(6), 501-512.

4. www.britannica.com/science/chemistry/Chemistry-and-society [Retrieved on 20/11/2015]

5. Majhi S. and Maharana B. (2012). Research productivity of physical science disciplines in Sambalpur University (ORISSA): A Scientometric Study. *Journal of Arts, Science and Commerce,* 4(1), 108-115.

6. Markandeya S.G. (2010). Collaborative RandD Activities under BRNS: Past, Present and Future – An Overview. *BARC Newsletter*, 316, 75-86.

7. Bala A. and Gupta B.M. (2010). Mapping of Indian neuroscience research: A scientometric analysis of research output during 1999-2008. *Neurology India,* 58(1), 35-41.

8. Sangam S.L. and Shivaranjini S. Mogali (2014). Mapping of Indian Social Science Literature. *Collnet Journal of Scientometrics and Information Management*, 8(1), 61-80

9. Davis M. and Wilson C.S. (2003). Research contributions in ophthalmology: Australia's productivity. *Clinical and Experiment Ophthalmology*, 31(4) 286-293

10. Garg K.C., Kumar S., Madhavi Y. and Bahl M. (2009). Bibliometrics of global malaria vaccine research. *Health Information and Libraries Journal*, 26(1) 22-31.

11. Gunasekaran S. (2006). Mapping chemical science research in India: A bibliometric study, *Annals of Library and Information Studies,* 53*,* 83-95.

12. Karki M.M.S. and Garg K.C. (1997). Bibliometrics of Alkaloid Chemistry Research in India. *Journal of Chemical Information and Computer Sciences,* 37*,* 157-161.

13. Machul A. and et al. (2015). Study on inhibitory activity of chitosan-based materials against biofilm producing Pseudomonas aeruginosa strains. *Journal of Biomaterials Applications*, 30(3), 269-278.

14. Maharana B., Majhi S. and Sethi B.B. (2011). Citation analysis of top research papers in chemistry with specific reference to India. *Library Review,* 60(6), 501-512.

15. Ramakrishnan J. and Thavamani K. (2013). Indian Contributions to the Field of Leptospirosis (2006-2013): A Bibliometric Study. *Collnet Journal of Scientometrics and Information Management,* 9(2), 235-249.

16. Roa C.N.R. and et al. (2009). ChemInform Abstract: Graphene: The New Two-Dimensional Nanomaterial *Angewandte Chemie International Edition*, 48, 7752 – 777.

17. Schubert A., Glänzel W. and Braun T. (1989). Scientometric datafiles. A comprehensive set of indicators on 2649 journals and 96 countries in all major science fields and subfields 1981–1985. *Scientometrics,* 16(1), 3-478.

18. www.emeraldinsight.com/toc/cb/32/1 (2015)

19. www.isiknowledge.com (2015)

20. www.isiknowledge.com (2015)