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Research and citation impact of publications by the Chemistry Division at Bhabha Atomic Research Centre

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The paper analyses the citations to 1733 publications published during 1970–1999 by the Chemistry Division at Bhabha Atomic Research Centre, using Science Citation Index 1982–2003 as the source data. The extent of citations received, in terms of the number of citations per paper, yearwise break up of citations, domainwise citations, self-citations and citations by others, diachronous self-citation rate, citing authors, citing institutions, highly cited papers, the categories of citing documents, citing journals and distribution of citations among them etc. are determined. During 1982–2003 chemistry Division publications have received a total of 11041 citations. The average number of citations per year was 501.86. The average number of citations per publication was 6.37. The highest number of citations received were 877 in 2001. The citation rate was peaked during 1990–2003 as maximum 9145 (82.82%) citations were received during the period. Total self-citations were 3716 (33.66%) and citations by others were 7325 (66.34%). Mean diachronous self-citation rate was 36.16. Citation time lag was zero for 144 (15.52%) papers and one year for 350 (37.72%) papers. Single authored publications (168) have received 456 (4.13%) citations and 1565 multi-authored publications have received 10585 (95.87%) citations. The core citing authors were: J. P. Mittal (695) followed by V. K. Jain (524), H. Mohan (471), T. Mukherjee (307), R. M Iyer (253), H. Pal (251), J. V. Yakhmi (211), A. V. Sapre (174), D. K. Palit (161), N. M. Gupta (128), and S. K. Kulshrestha (116). Citation life cycles of four highly cited papers was discussed. The core journals citing Chemistry Division publications were: *J. Phys. Chem.–A* (436 citations), *Chem. Phys. Lett.* (372), *J. Phys. Chem.* (355), *J. Chem. Phys.* (353), *J. Organomet. Chem.* (285), *J. Phys. Chem.–B* (279), *J. Photochem. Photobiol.–A* (263), *Langmuir* (245), *J. Am. Chem. Soc.* (226), *Physica–C* (225), *Radiat. Phys. Chem.* (217), *Inorg. Chem.* (215) and *Indian J. Chem.–A* (207).

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Introduction

Research is a complicated process involving very often a large number of intricate issues, and evaluation of scientific activity is still more complicated. Evaluation is a very important component of any research and development activity in an institution. Evaluating science has become a major aim for those dealing with decision making for the management of science. MARTIN & IRVIN (1983) have thoroughly reviewed about the basic research inputs and outputs and various possible assessment methods. They also considered the count of scientific publications and citations, and peer evaluation methods providing characteristic indicators. Publication and citation counting techniques have been used in the assessment of scientific activity for at least fifty years. During the half-century of this activity the main thrust of interest seems to flow along two connected but parallel paths: the bibliometric path of publication and citation counts as tools for the librarian, and an evaluative path using these same tools to illuminate the mosaic of scientific activity (NARIN, 1976). LAHARIA & SINGH (1987) have discussed the various approaches used to measure the scientific productivity and LANCASTER (1991) has suggested bibliometric measures of productivity and impact in research.

Citation brings out the connection between two documents; the one which cites and the other which is cited. The act of citing in general, an expression of the importance of the material cited, as authors often refer to previous material to support, illustrate or elaborate on a particular point (GARFIELD, 1978, 1994). A highly cited work, naturally, is the one that has been found to be useful by relatively large number of authors, or in relatively large number of experiments. Citation count is, therefore, a measure of scientific activity, utility and impact of scientific work. However, citation counts do not say anything about the nature, utility or impact of the work (GARFIELD, 1979).

Citation analysis constitutes an important tool in quantitative studies of science and technology. To assess the quality of a given publication, the number of times it has been cited in the literature can be counted. Similarly, the number of times a person has been cited in the literature can be taken as a measure of the quality of that person's work (GARFIELD, 1979, 1994; LAWANI, 1977; MORAVCSIK, 1976; NARIN et al., 1983; SMITH, 1981; WALLMARK & SEDIG, 1986). Citation analysis is a more complex task than is often recognized in the sense that it requires careful identification of exactly what is being analysed. Every citation represents a decision of the author to draw attention to the work of another as being relevant to his theme at a particular point in the document he is writing (SANDISON, 1989).Citation counts not only help a research administrator to assess the quality of each individual scientist but also that of his organization as a whole. A few studies of this sort on individual Institutions/departments have been conducted all over the world (SALISBURY, 1980; COHEN, 1981; SCHUBERT & BRAUN, 1981; YANKEVICH, 1982; CARPENTER et al., 1988; GARG & RAO, 1988; VINKLER,

1990; KALYANE & KALYANE, 1991; MINOR & DOSTATNI, 1991; DIZON & SADORRA, 1995; UGOLINI et al., 1997; KING, 1998; GUPTA et al., 1999; ZACHOS, 1991; FROHLICH & RESLER, 2001; KOGANURAMATH et al., 2002; LEE, 2003; SCHLOEGL et al., 2003). Many studies have been conducted to evaluate the chemistry research. GUAY (1986) studied the emergence of organic chemistry research in India during 1907–1926 covered by *Chemical Abstracts*. KLAIC (1990) analysed 2018 papers published during 1976–1985 by the chemists from the Rugjer Bošković Institute in Yugoslavia, using both publications and citation counts were used for the analysis. Adopting similar method, KIM & KIM (2000) examined research performance of Chemists, analyzing a total of 651 papers published by the 29 faculty members at the Chemistry Department, Seoul National University, Korea, from 1992–1998. BISHOP et al.(2003) reviewed the work of the Chemoinformatics Research Group in the Department of Information Studies at the University of Sheffield during 1985–2002. The study also carried out the citation analysis of 321 papers published during 1980–2002. VINKLER (2004) used special scientometric indicators for evaluating publication activity of research teams for about 30 years in the Chemical Research Centre of the Hungarian Academy of Sciences. KADEMANI et al. (2005) have carried out the publication productivity of 1733 papers published during 1970–1999 by the Chemistry Division at Bhabha Atomic Research Centre. KADEMANI et al. (2005; 2006) have also carried out publication productivity of the Bio-organic Division and Analytical Chemistry Division at Bhabha Atomic Research Centre.

The unit of study in citation analysis can be any form of written communication or an author, an organization or a nation (SMALL & GREENLEE, 1979). However, citation counts cannot be taken as the sole measure of quality, because numerous other factors affect scientists' work and the impact of their publications is only a measure of their overall influence. For instance, a scientist who spends most of his time on teaching may contribute in an indirect way to the future achievements of his institution. Sometimes a scientist may require years of background work to prepare a paper and that single paper itself would be a vital contribution having more value than that of publications of other prolific authors. Nevertheless, and scientists themselves are almost invariably keen to see this kind of information (MARTYN, 1975; CRONIN, 1984; MAC ROBERTS & MAC ROBERTS, 1989; BROWN, 1993; MAHAJAN, 1993). One should be very careful while collecting and carrying out citation analysis as it may contain some discrepancies (GARFIELD, 1977; MOED & VRIENS, 1989). LIU (1993) reviewed on the citation studies that have dealt with citation functions, citation quality, citation concept and citation motivation. Citation analysis as a subject remains controversial (TAUBE, 1993). ROUSSEAU (1995) proposed a framework within which citations can be used for evaluation purposes.

Chemistry Division is one of the oldest divisions of Bhabha Atomic Research Centre established in the early stages of Department of Atomic Energy to carry out research and developmental activities relevant to atomic energy programmes (VENKATESWARLU & GEORGE, 1998). KADEMANI et al. (2005) have carried out the publication productivity of the Chemistry Division. The present study attempts to carry out citation analysis of publications of the Chemistry Division published during 1970–1999.

Objectives

The main objective of the study is to highlight the citation impact of publications by the Chemistry Division at Bhabha Atomic Researh Centre (BARC), specifically to highligh the following:

- to identify the extent of citations received to the publications of Chemistry Division at Bhabha Atomic research Centre,
- to find out yearwise growth of citations to Chemistry Division publications,
- to find out the time lag between publication of a paper and its getting first citation,
- to find out dmainwise distribution of citations,
- to differentiate the citation pattern of publications with authorships in the cited articles,
- to identify highly cited papers of the Chemistry Division and their citation life cycle,
- to prepare a core citing group that cited Chemistry Division publications,
- to identify the institutions in the citing papers of Chemistry Division publications,
- to find out the distribution of citing papers of Chemistry Division publications according to country of publishing publications,
- to find out types of documents citing Chemistry Division publications,
- to prepare a list of citing journals and ascertain their characteristics,
- to examine the scattering of citations among journals,
- to find out the distribution of the citing journals according to impact factors,
- to draw Bradford-Zipf citograph, and
- to analyse the keywords of citing documents to asses the influence of Chemistry Division publications on other areas of research.

Materials and methods

Chemistry Division of Bhabha Atomic Research Center has published a total of 1733 publications during 1970–1999. The present citation analysis study coverd the period from 1982–2003. All the 1733 papers published during 1970–1999 have been considered for the analysis. For calculating the time lag, papers published during 1982–1999 have been considered. Citations were collected for each paper from the Science Citation Index-On Disc (CD-ROM) (1982–2003) published by the Institute of Scientific Information, Philadelphia. All the data elements were transferred to spread sheet application. After data validation, analysis was carried out as per objectives of the study. Some papers published during 1970–1981 might have received good number of citations. Due to the non availability of data for the above period the study will not be able to clearly ascertain the number of citations received to the papers. Therefore, the analysis may be viewed subject to this limitations.

Results and discussion

Year-wise growth of citations

Chemistry Division of Bhabha Atomic Research Centre had published a total of 1733 papers during 1970–1999 in various domains: Radiation & Photochemistry and Chemical Dynamics (649), Solid State Studies (558), Inorganic, Structural and Materials Chemistry (460) and Theoretical Chemistry (66). KADEMANI et al. (2005) have studied the publication productivity of these publications. The present study tried to find out the impact of Chemistry Division publications by way of citation analysis. During 1982–2003 chemistry Division publications have received a total of 11041 citations. The average number of citations per year was to 501.86. The average number of citations per publications was 6.37. The highest number of citations received were 877 in 2001. The continuous growth of citations was found through out. The citation rate was peaked during 1990–2003 as the maximum 9145 (82.82%) citations were received during the period. The main reason for receiving more citations during this period as 784 (45.23%) papers were published during 1990–1999 and some important papers published earlier have continued to receive citations. This indicates that quality and quantity always go hand in hand. The receipt of citations to publications is directly proportional to the number of papers published. This indicates that during 1990–1999 more number of scientists produced more number of highly qualitative publications. It is too early to predict the rate of receipt of citations to Chemistry Division publications has slowed down as many of the papers are still attracting good number of citations. Figure 1 presents the growth of citations, self-citations, citations by others and cumulative citations.

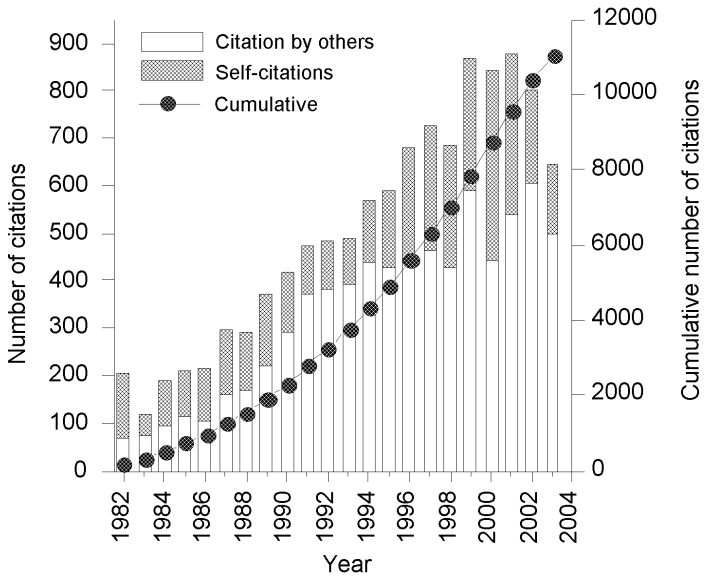

Figure 1. Growth of citations to Chemistry Division publications

Total self-citations were 3716 (33.66%) and citations by others were 7325 (66.34%). The highest number of self-citations were 400 in 2000. The highest number of citations by others were 606 in 2002. The high rate of author self-citation may be due to authors work in a very new and narrow field of specialization, very sparsely populated field have no option except to cite their own work and importantly authors who publish more will have a chance to cite their own previously published work. GAMI et al. (2004) found in their investigation of author self-citations that nearly one fifth of all citations per year were self-citations. They found no relation between quality of article and frequency of author self-citation. Articles published in highly cited journals had a smaller proportion of author self-citations than articles published in less-cited journal. GLÄNZEL et al. (2004) analysed the role of author self-citations to find out basic regularities of self-citations in the process of scientific communication for laying methodological basis. Mean diachronous self citation rate was 36.16 (n = 1192). LAWANI (1982) has defined diachronous self citation rate as follows.

$$\text{Diachronous Self–Citation Rate} = \frac{\text{Self citations to an article in SCI database}}{\text{Total number of citations received to an article in SCI database}} \times 100$$

Out of 1733 papers, 1192 papers have received citations and 541 papers have not received any citations. Out of 541 papers, 211 papers were published during 1970–1981 and 330 papers were published during 1982–1999. Table 1 gives the number of papers and their citedness.

Table 1. Distribution of Chemistry Division publications on the basis of citations received

Number of citations	Number of papers	Total number of citations	Cumulative	Number of citations	Number of papers	Total number of citations	Cumulative
0	541	0	0	32	3	96	8089
1	205	205	205	33	6	198	8287
2	157	314	519	34	5	170	8457
3	97	291	810	35	3	105	8562
4	70	280	1090	36	3	108	8670
5	83	415	1505	37	2	74	8744
6	74	444	1949	38	1	38	8782
7	59	413	2362	39	1	39	8821
8	55	440	2802	40	2	80	8901
9	33	297	3099	41	1	41	8942
10	56	560	3659	42	1	42	8984
11	21	231	3890	43	1	43	9027
12	26	312	4202	45	4	180	9207
13	24	312	4514	47	2	94	9301
14	20	280	4794	49	1	49	9350
15	22	330	5124	52	1	52	9402
16	13	208	5332	53	4	212	9614
17	15	255	5587	54	1	54	9668
18	17	306	5893	55	2	110	9778
19	13	247	6140	56	1	56	9834
20	9	180	6320	60	2	120	9954
21	11	231	6551	62	1	62	10016
22	5	110	6661	66	1	66	10082
23	6	138	6799	68	1	68	10150
24	9	216	7015	70	1	70	10220
25	5	125	7140	85	1	85	10305
26	9	234	7374	97	1	97	10402
27	4	108	7482	108	1	108	10510
28	2	56	7538	115	1	115	10625
29	2	58	7596	188	1	188	10813
30	6	180	7776	228	1	228	11041
31	7	217	7993	Total	1733	11041	–

There is always some percentage of papers remain uncited for variety of reasons. The contents of the papers may be ahead of time and beyond the grasp of contemporary scientists, important paper published in an obscure journal, etc. GHOSH & NEUFELD (1974) have studied the uncitedness of articles in the *Journal of American Chemical Society* and found that only 14.7 per cent were not cited during any given year. GHOSH

(1974) has also studied the uncitedness of articles in the multidisciplinary scientific journal *Nature* and found that an average of 48.6% of the test papers from *Nature* were uncited. STERN (1990) has conducted a study to determine the bibliographic characteristics of uncited papers in biomedical literature and found that certain bibliographic characteristics differentiate cited from uncited papers. KADEMANI & KALYANE (1996) have compared thirteen papers considered by the scientist as most significant with citations received to these publications and found that four papers were outstandingly cited, four were remarkably cited, one was fairly cited, one paper was poorly cited and two papers were uncited. This indicates that self assessment by a scientist, about the significance of his papers may not always tally with the world opinion. SHARMA & SEN (2005) have stated that it is very difficult to find out the reasons for uncitedness for significant contributions as there is no easy mechanism available other than through citations.

Citation time lag

Citation time lag is one of the indicators which may throw light on independence of research programs or individual scientists. Usually, scientific papers are published before the citing paper or perhaps in the same year. That is, time lag is positive, or zero, time lag being the difference between the year of citing and the year of cited paper. The average value of time lag within a particular citing paper or series of papers reflects how modern the paper is or how integrated it is in the evolving research front. In rapidly evolving 'hot' areas time lag will be small and in many cases zero. If time lag is large, say ten years, it usually indicates that the paper or series of papers belongs to a stagnating research area or is out of contact with main stream of research.

For calculating the time lag, papers published during 1982–1999 have been considered. There were 1258 papers published during 1982–1999. Out of 1258 papers, 330 (26.23%) papers remain uncited. Hence only 928 papers were considered for calculating the time lag. Time lag between publication of an article and its receiving first citation in the case of Chemistry Division publications is in the range of 0 to 20 years. It was revealed that 144 (15.52%) papers received citations in the same year of publication, followed by 350 (37.72%) papers received citations after one year of publication, 198 (21.34%) papers received citations after two years of publication, 98 (10.56%) papers received citations after three years of publication, 39 (4.20%) papers received citations after four years of publication, and 29 (3.13%) papers received citations after five years of publication. It is found that 92.45 percent of the papers have received their first citations within five years of their publication indicates that Chemistry Division publications were noticed instantly and had immediate direct impact among the fellow researchers working all over the world in this field. This also indicated that the publications were well integrated in the evolving research front. Only

15 (1.61%) papers received citations after 10 years which is very negligible. In this case the contents of some of the papers may be well ahead of time or published in the channels which are not well known and hence did not attract immediate citations. Figure 2 gives number of papers and the citation time lag. The speed at which the publication is disseminated to the scientific community also one of the important factors that affects the publication getting noticed for the first time.

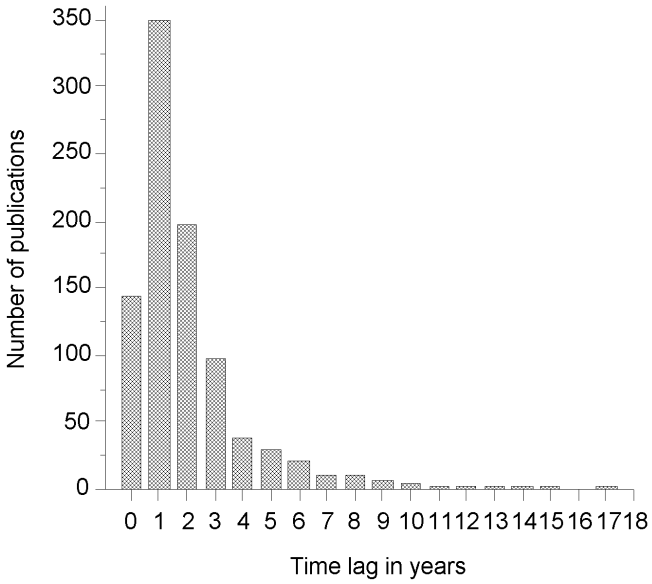

Figure 2. Citation time lag for Chemistry Division publications

Domain-wise distribution of citations

Chemistry Division has contributed significantly to four main domains : Radiation & Photochemistry and Chemical Dynamics with 649 publications, Solid State Studies with 558 publications, Inorganic, Structural and Materials Chemistry with 460 publications and Theoretical Chemistry with 66 publications during 1970–1999. The citation pattern in each domain is given in Figures 3a, 3b, 3c, and 3d. Domain 'Radiation & Photochemistry and Chemical Dynamics' has received 5244 (47.50%) citations followed by, 'Solid State Studies' with 3261(29.53%) citations, Inorganic, 'Structural and Materials Chemistry' with 2493 (22.57%) citations and 'Theoretical Chemistry' with 43 (0.40%) citations. There were no citations during1983–1984 and 1995–1996 to 'Theoretical Chemistry' domain. The citation rate depends on variety of factors such as the number of people working, number of papers published, type publications, the area of research (highly specialized or broad) etc.

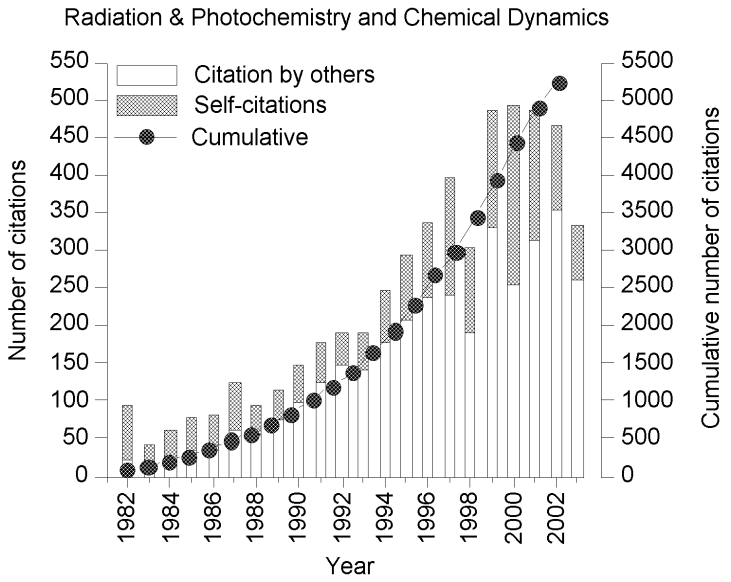

Figure 3a. Citation pattern in the domain Radiation & Photochemistry and Chemical Dynamics

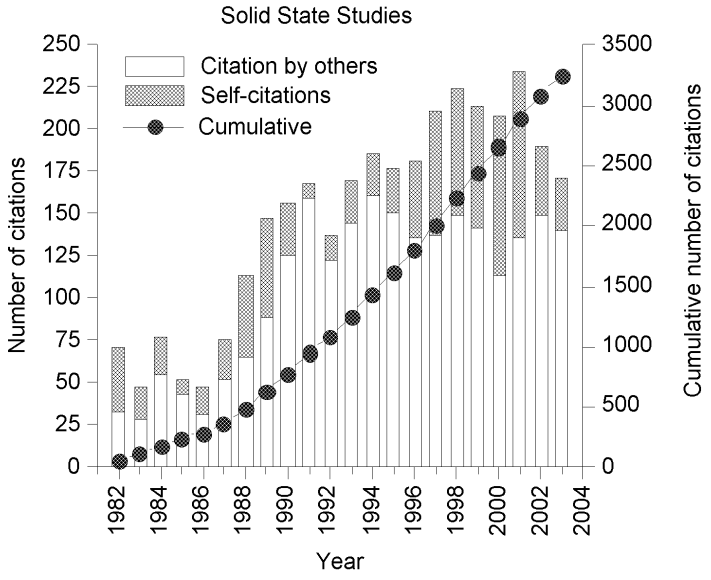

Figure 3b. Citation pattern in the domain Solid State Studies

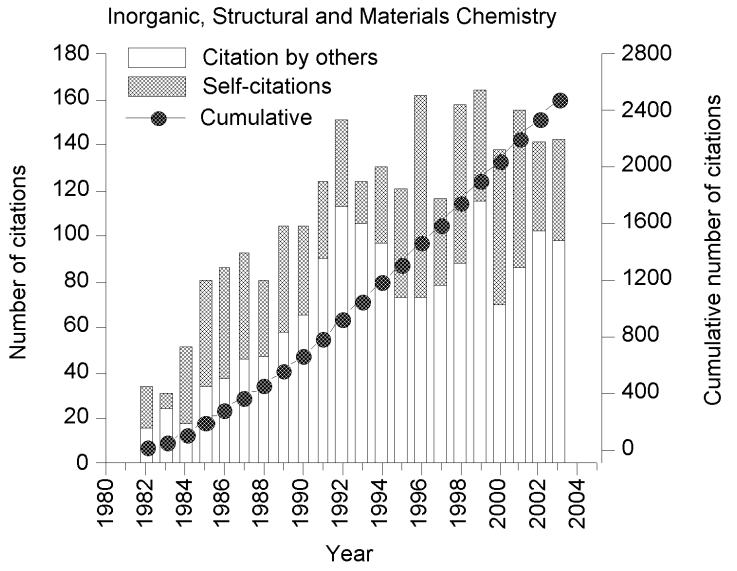

Figure 3c. Citation pattern in the domain Inorganic, Structural and Materials Chemistry

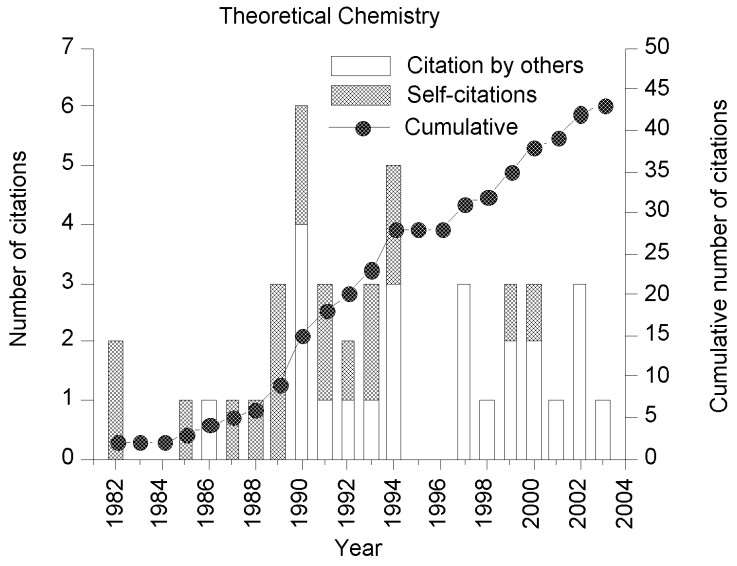

Figure 3d. Citation pattern in the domain Theoretical Chemistry

Communication pattern tend to be quite different in different fields. Some fields have many practitioners, some have a few. In some areas 'invisible colleges' are very well developed and active, whereas in other areas they are not so active. Some fields are characterized by careful and substantial publications, others have a hectic assortment of feuilleton type articles. In some fields the ratio of activity to productivity, and productivity to progress, rather large, while in others small. Direct comparison of two faculty members at a university, one working in a small and careful field and other in a large and hectic one, by simply counting up their publications or citations is clearly unfair, and even grossly so. Similarly different countries might have substantially different mixes of various scientific areas and hence their publications or citation ratings are really incomparable. Finally at different times scientists work on different types of problems which possibly have different publications and citation pattern (MORAVCSIK, 1973).

Citations vs authorship pattern

Jointly authored papers tend to be cited more than others. In fact, the more authors a paper has, the more likely it is to be cited. For the field of cancer research, LAWANI (1980) has shown clearly that citation rate and quality of paper (as judged by a forum of peer review) both correlate positively with the number of authors per paper. SMART & BAYER (1986) stated that the acceptance rate of articles which are collaboratively authored tends to be higher than that for single authored papers, thereby suggesting a generally positive relationship between collaboration and quality. The analysis of ten year citation rates of 270 randomly selected articles in three applied fields likewise shows a similar relationship, with somewhat higher citation frequencies for multi-authored papers than for single authored ones. The relationship persist whether self-citations are included or excluded. However, those differences are not statistically significant for articles in clinical psychology or educational measurement. Only multi-authored articles in management science show a statistically significant higher citation rate.

The number of citations received in relation to authorship pattern in the publication of Chemistry Division is given in Figure 4. Single authored publications (168) have received 456 (4.13%) citations and 1565 multi-authored publications have received 10585 (95.87%) citations. Maximum 2849 (25.80%) citations were for three authored publications followed by four authored publications with 2737 (24.79%) citations, two authored publications with 2029 (18.38%) citations, five authored publications with 1450 (13.13%) citations, six authored publications with 780 (7.06%) citations, seven authored publications with 529 (4.79%) and eight authored publications with 153 (1.39%) citations.

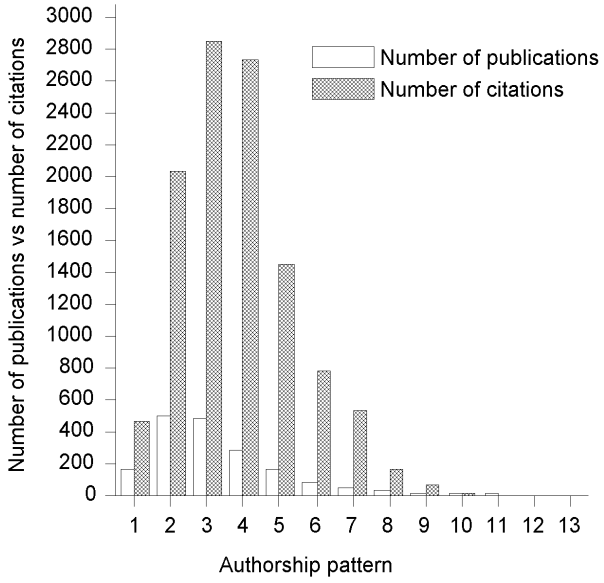

Figure 4. Authorship pattern and citations to Chemistry Division publications

The authorship-wise distribution of Chemistry Division publications in national and international channels is given in Table 2. During the period covered in the study Chemistry Division has published 1733 papers, of which 432 (24.93%) were published in Indian channels of communications and 1301 (75.07%) in international channels. The former papers have received 627 (5.68%) citations while the latter have received 10414 (94.32%). The number of citations received per paper was 1.45 for the publications in national channels and 8.00 for the publications in international channels. Maximum citations 2702 were for four-authored papers published in journals of international scope. Among the papers published in Indian journals, the maximum number of citations 313 were scored by the three-authored papers.

Table 2. Authorship distribution of papers and citations of Chemistry Division publications in national and international channels

Author-ships	Papers published in the channels			Citations received to papers published in the channels			% of citations		Citations/paper	
	National	Inter-national	Total	National	Inter-national	Total	National	Inter-national	National	Inter-national
1	66	102	168	66	390	456	14.47	85.53	1	3.82
2	161	332	493	151	1878	2029	7.44	92.56	0.94	5.66
3	134	351	485	313	2536	2849	10.99	89.01	2.34	7.23
4	38	230	268	37	2700	2737	1.35	98.65	0.97	11.74
5	21	146	167	24	1426	1450	1.66	98.34	1.14	9.77
6	7	72	79	27	753	780	3.46	96.54	3.86	10.46
7	2	34	36	4	525	529	0.76	99.24	2	15.44
8	1	20	21	1	152	153	0.65	99.35	1	7.6
9	0	8	8	2	50	52	3.85	96.15	0	6.25
10	1	2	3	1	3	4	25	75	1	1.5
11	0	3	3	0	1	1	0	100	0	0.33
12	1	0	1	1	0	1	100	0	1	0
13	0	1	1	0	0	0	0	0	0	0
Total	432	1301	1733	627	10414	11041				
Percent	24.93	75.07	100	5.68	94.32	100				
Citation/ Paper	1.45	8								

Core authors citing Chemistry Division publications

All the authors appeared in the citing papers were counted. In all, there were 14110 authors in the papers citing Chemistry Division publications and have produced 38558 authorships. Citing authors with authorships more than 30 are listed in the Table 3. This indicates how well populated and highly integrated the research carried out in the Chemistry Division at BARC with the mainstream of research. The core citing authors were obviously from the Chemistry Division itself. It is interesting to note that most of the core citing authors are also the highly productive scientists. The core citing authors whose names have appeared in the citing papers of Chemistry Division publications with their authorships in citing papers were J. P. Mittal (695) followed by V. K. Jain (524), H. Mohan (471), T. Mukherjee (307), R. M Iyer (253), H. Pal (251), J. V. Yakhmi (211), A. V. Sapre (174), D. K. Palit (161), N. M. Gupta (128), S. K. Kulshrestha (116), R. J. Butcher (113), P. N. Moorthy (111), I. K. Gopalakrishnan (106), S. N. Guha (101), and K. I. Priyadarshini (101).

Table 3. Core citing authors with authorships ≥30

Citing Authors	Authorships	Rank	Citing Authors	Authorships	Rank
Mittal-JP	695	1	Rao-BSM	62	30
Jain-VK	524	2	Chowdhury-PK	61	31
Mohan-H	471	3	Tiekink-ERT	60	32
Mukherjee-T	307	4	Venkataramani-B	60	32
Iyer-RM	253	5	Singh-HB	58	33
Pal-H	251	6	Gopinathan-C	57	34
Yakhmi-JV	211	7	Sathyamoorthy-A	57	34
Sapre-AV	174	8	Shoute-LCT	57	34
Palit-DK	161	9	Goodwin-HA	55	35
Gupta-NM	128	10	Kaim-W	55	35
Kulshreshtha-SK	116	11	Kishore-K	55	35
Butcher-RJ	113	12	Nandan-D	55	35
Moorthy-PN	111	13	Rao-KVSR	55	35
Gopalakrishnan-IK	106	14	Singh-AK	55	35
Guha-SN	101	15	Adhikari-S	53	36
Priyadarsini-KI	101	15	Kadam-RM	53	36
Kannan-S	87	16	Fujitsuka-M	52	37
Rath-MC	87	16	Gupta-AR	51	38
Maity-DK	86	17	Kumar-A	51	38
Rao-KN	86	17	Nad-S	51	38
Singhal-A	85	18	Phillips-DL	51	38
Ghosh-HN	84	19	Narayan-S	50	39
Ito-O	82	20	Alberts-HL	49	40
Vatsa-RK	79	21	Mugesh-G	49	40
Kamble-VS	78	22	Narayanan-J	49	40
Raj-P	78	22	Ritter-G	49	40
Volpp-HR	78	22	Brownsword-RA	48	41
Asmus-KD	76	23	Bohra-R	47	42
Konig-E	76	23	Mokal-VB	47	42
Manohar-C	76	23	Sastry-MS	47	42
Sarkar-SK	76	23	Schoneich-C	45	43
Sastry-MD	75	24	Land-EJ	44	44
Neta-P	70	25	Parthasarathy-V	43	45
Kamat-PV	67	26	Swallow-AJ	43	45
Dey-S	66	27	Zarembowitch-J	43	45
Kahn-O	66	27	Lian-TQ	42	46
Sastry-PVPSS	65	28	Varghese-B	42	46
Kapoor-S	64	29	Guldi-DM	41	47
Bhasikuttan-AC	62	30	Goyal-PS	40	48

Table 3. cont

Citing Authors	Authorships	Rank	Citing Authors	Authorships	Rank
Knoedler-A	40	48	Panda-A	34	53
Sequeira-A	40	48	Bruce-JM	33	54
Shashikala-K	40	48	Hendrickson-DN	33	54
Lal-M	39	49	Ramamurthy-P	33	54
Nayak-AK	39	49	Somasundaran-P	33	54
Wolfrum-J	39	49	Vonsonntag-C	33	54
Gawandi-VB	38	50	Chaudhury-S	32	55
Gutlich-P	38	50	Laurent-T	32	55
Kumar-M	38	50	Sun-YP	32	55
Naik-DB	38	50	Venkateswarlu-KS	32	55
Rao-MH	38	50	Fawcett-E	31	56
Asbury-JB	37	51	Martire-DO	31	56
Hassan-PA	37	51	Shastri-LV	31	56
Joshi-R	37	51	Suryanarayana-P	31	56
Kunjappu-JT	37	51	Wang-Y	31	56
Chattopadhyay-S	35	52	Gratzel-M	30	57
Hillenkamp-M	35	52	Ma-CL	30	57
Naik-PD	35	52	Rajagopal-H	30	57
Nath-S	35	52	Rao-URK	30	57

truncated

Sectoral distribution of citing institutions

In all, there were 2357 institutions appeared in the citing papers. These institutions have been grouped into three distinct categories as (a) Academic Institutions (b) Research Institutions and (c) Commercial Organizations based on the institutional address given in the author's affiliation field in the citing papers. Academic Institutions were identified by the appearance of terms such as University, Academy, individual Departments/Institutions, Collages under the purview of University or Academy. The Commercial Organizations were identified based on the terms such as Co., Ltd., Inc., and Ind., and rest were considered as Research Institutions. Figure 5 shows the sector wise break up of citing institutions. The analysis showed that Academic Institutions by far largest citing group of Chemistry Division Publications with 54.80% followed by Research Institutions with 44.02% and Commercial Organizations with 1.18%.

A few important institutions in each category were : University of Paris with 223 frequencies followed by University of Notre Dame with 165 frequencies, Russian Academy of Science with 162 frequencies and University of Erlangen-Nurenerg with 135 frequencies under Academic Institutions category; Bhabha Atomic Research Center with 3829 frequencies followed by Indian Institute of Science with 237 frequencies, Indian Institute of Technology, Mumbai with 186 frequencies and Jawaharlal Nehru

Centre for Advance Research with 114 frequencies under Research Institutions category and Atomic Energy Canada Ltd. with 19 frequencies and, Ministry of Trade and Industries, Japan with 10 frequencies under Commercial Organizations category. Table 4 gives the core citing institutions based on their frequency of appearance in the citing papers.

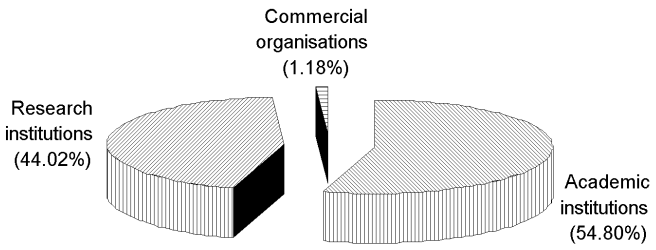

Figure 5. Sectoral distribution of institutions citing Chemistry Division publications

Country-wise distribution of citing publications

All the countries appeared in the country of affiliation field in the citing papers were counted. In all, there were 102 countries in the citing papers with a total of 18315 frequencies. The most frequently occurred countries in the citing papers were : India with 5673 frequencies followed by USA with 2916 frequencies, Japan with 1178 frequencies, France with 944 frequencies, Germany with 830 frequencies, England with 659 frequencies, and People of Republic of China with 583 frequencies. Figure 6 gives the countries with high frequencies appeared in the citing papers. This indicates that more number of foreign papers (69.03%) have cited Chemistry Division publications.

Highly cited papers of Chemistry Division

Twenty one highly cited papers of Chemistry Division could be identified as these papers have received more than 50 citations. Citation life cycles of the four highly cited papers have been given in Figures 7a, 7b, 7c, and 7d. Bibliographic details of all the 21 highly cited papers are given in Table 5.

Table 4. Core institutions citing Chemistry Division publications

Rank	Citing Institutions	%	Frequency
1	BHABHA-ATOM-RES-CTR, INDIA	20.91	3829
2	INDIAN-INST-SCI, INDIA	1.29	237
3	UNIV-PARIS, FRANCE	1.22	223
4	INDIAN-INST-TECHNOL-MUMBAI-INDIA	1.02	186
5	UNIV-NOTRE-DAME, USA	0.90	165
6	RUSSIAN-ACAD-SCI, RUSSIA	0.88	162
7	UNIV-ERLANGEN-NURNBERG, GERMANY	0.74	135
8	HOWARD-UNIV, USA	0.68	124
9	TOHOKU-UNIV, JAPAN	0.67	123
10	JAWAHARLAL-NEHRU-CTR-ADV-RES, INDIA	0.62	114
11	CHINESE-ACAD-SCI, PEOPLES-R-CHINA	0.55	101
12	CNRS, FRANCE	0.51	93
13	UNIV-HEIDELBERG, GERMANY	0.49	89
14	UNIV-RAJASTHAN, INDIA	0.48	87
15	INDIAN-INST-TECHNOL-Chennai-INDIA	0.45	83
16	OSAKA-UNIV, JAPAN	0.45	82
17	UNIV-POONA, INDIA	0.42	77
18	ARGONNE-NATL-LAB, USA	0.40	74
19	HAHN-MEITNER-INST-BERLIN-GMBH, GERMANY	0.40	73
20	CHRISTIE-HOSP-HOLT-RADIUM-INST, ENGLAND	0.38	70
20	UNIV-CALIF-BERKELEY, USA	0.38	70
21	HEBREW-UNIV-JERUSALEM, ISRAEL	0.38	69
22	KYUSHU-UNIV, JAPAN	0.37	68
22	NATL-INST-STAND-TECH, USA	0.37	68
22	UNIV-TOKYO, JAPAN	0.37	68
23	UNIV-TORONTO, CANADA	0.37	67
24	MAX-PLANCK-INST-STRAHLENCHEM, GERMANY	0.36	66
25	UNIV-NEW-S-WALES, AUSTRALIA	0.35	64
26	BEN-GURION-UNIV-NEGEV, ISRAEL	0.34	63
27	TATA-INST-FUNDAMENTAL-RES, INDIA	0.34	62
28	UNIV-MADRAS, INDIA	0.33	61
28	UNIV-STUTTGART, GERMANY	0.33	61
29	TECH-UNIV-LODZ, POLAND	0.33	60
30	UNIV-MISSOURI, USA	0.32	59
31	EMORY-UNIV, USA	0.31	57
32	UNIV-ADELAIDE, AUSTRALIA	0.31	56
32	UNIV-ILLINOIS, USA	0.31	56
33	CNR, ITALY	0.30	55
33	OAK-RIDGE-NATL-LAB, USA	0.30	55
34	UNIV-HONG-KONG, PEOPLES-R-CHINA	0.29	54
35	UNIV-SCI-TECH-CHINA, PEOPLES-R-CHINA	0.28	52
36	KYOTO-UNIV, JAPAN	0.28	51
37	COLUMBIA-UNIV, USA	0.27	50
37	RAND-AFRIKAANS-UNIV, SOUTH-AFRICA	0.27	50
37	UNIV-COMPLUTENSE, SPAIN	0.27	50
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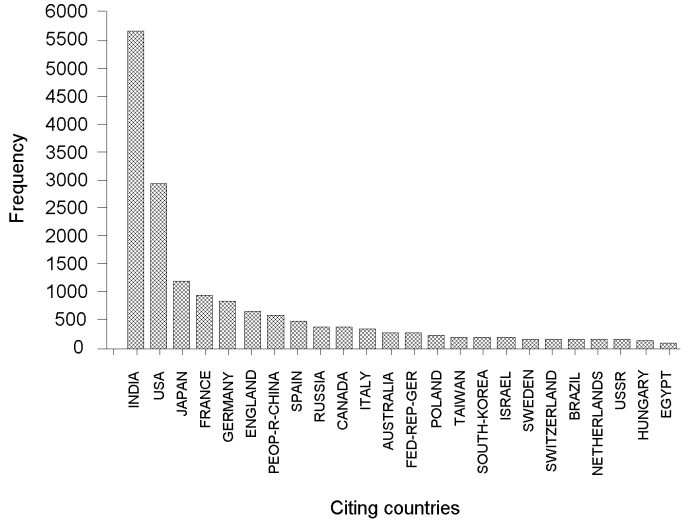

Figure 6. Distribution of countries citing Chemistry Division publications

The paper P1 has received total 228 citations during 1985–2003, out of which 14 were self citations. This paper has received citations in the same year of its publication and continue to receive citations till the period under study. The average citations per year was 12. The highest citations 20 were received in 1987. There were 69 journals citing this paper. Diachronous self-citation rate was 6.14.

The paper P2 has received 188 citations during 1994–2003, out of which 58 were self citations. This paper has received citations in the same year of its publication and continue to receive citations till the period under study. There were only self citations in 2000 and 2001 for this paper. The average citations per year was 18.80. The highest citations 35 were received in 1997. There were 40 journals citing this paper. Diachronous self-citation rate was 30.85.

The paper P3 has received 115 citations during 1993–2003, out of which 25 were self citations. This paper has received citations after one year of its publication and continue to receive citations till the period under study. There is a declining trend of citations for this paper. There were only self citations in 1998 for this paper.The average citations per year was 9.58. The highest citations 17 were received in 1993. There were 42 journals citing this paper. Diachronous self-citation rate was 21.74.

The paper P4 has received 108 citations during 1998–2003, out of which 18 were self citations. This paper has received citations in the same year of its publication and continue to receive citations till the period under study. The average citations per year was 18.00. The highest citations 33 were received in 2000. There were 30 journals citing this paper. Diachronous self-citation rate was 16.67.

Table 5. Highly cited papers of Chemistry Division

Paper	Bibliographic details of Highly Cited Papers	SC	CO	TC	CTLY	DR
P1	E. Konig, G Ritter, S.K. Kulshreshtha.Nature of spin state transitions in solid Fe(II) complexes and its interpretation of some associated phenomena, *Chem Rev* V-85 P-219 (1985)	14	214	228	0	6.14
P2	E. Fawcett, H.L. Alberts, V.Yu. Galkin, D.R. Noakes, J.V. Yakhmi.Spin-density wave antiferromagnetism in chromium alloys, *Rev Mod Phys* V-66 P-25 (1994)	58	130	188	0	30.85
P3	D.K. Palit, A.V. Sapre, J.P. Mittal, C.N.R. Rao.Photophysical properties of the fullerenes, C60 and C70, *Chem Phys Lett* V-195 P-1 (1992)	25	90	115	1	21.74
P4	R. ElLingson, J.B. Asbury, S. Ferrere, H.N. Ghosh, T. Lian, A.J. Nozik.Dynamics of electron injection in nanocrystalline titanium dioxide films sensitized with [Ru(4, 4'-dicarboxy-2, 2-bipyridine)2(NCS)2] by infra-red transient absorption, *J Phys Chem B* V-102 P-6455 (1998)	18	90	108	0	16.67
P5	H.N. Ghosh, H. Pal, A.V. Sapre, J.P. Mittal.Charge recombination reactions photoexcited C6o-amine complexes picosecond - pumpnd probe studies, *J Am Chem Soc* V-115 P-1722 (1993)	30	67	97	1	30.93
P6	B.W. Statt, Z. Wang, M.I.G. Lee, J.V. Yakhmi, P.D. de Camargo, J.F. Major, I.W. Ritter.Stabilising the high Tc superconductor Bi2Sr2Ca2-Cu3O 10+x by Pb substitution, *Physica C* V-156 P-251 (1988)	10	75	85	1	11.76
P7	P. Somasundaram, J. T. Kunjappu.In-situ investigation of adsorbed surfactants and polymers on solids in solution, *Colloid Surface* V-37 P-245 (1989)	14	56	70	2	20.00
P8	P.D. Kale, H.T. Lokhande, K.N. Rao, M.H. Rao.Grafting on polyester fibres, *J Appl Polym Sci* V-19 P-461 (1975)	7	61	68	NA	10.29
P9	D.K. Palit, H.N. Ghosh, H. Pal, A.V. Sapre, J.P. Mittal, Ram Seshadri, C.N.R. Rao.Dynamics of charge transfer in the excited amine complexes of the fullerenes C60 and C70 : a picosecond laser photolysis study, *Chem Phys Lett* V-198 P-113 (1992)	13	53	66	1	19.70
P10	P.Neta, R.E. Huie, S. Mosseri, L.V. Shastri, J.P. Mittal, P. Maruthamuthu, S. Steenken.Rate constants for reactions of substituted methyl peroxy radicals with ascorbic acid, *J Phys Chem* US V-93 P-4099 (1989)	23	39	62	0	37.10
P11	E.J. Land, T. Mukherjee, A.J. Swallow, J.M. Bruce.One electron reduction of adriamycin : Properties of the semiquinone, *Arch Biochem Biophys* V-225 P-116 (1983)	17	43	60	1	28.33

Table 5. cont.

Paper	Bibliographic details of Highly Cited Papers	SC	CO	TC	CTLY	DR
P12	H.N. Ghosh, J.B. Asbury, T. Lian.Direct observation of ultrafast electron injection from coumarin 343 to TiO2 nanoparticles by femtosecond infrared spectroscopy, *J Phys Chem B* V-102 P-6482 (1998)	19	41	60	0	31.67
P13	B.S. Valaulikar, C. Manohar.The mechanism of clouding in Triton X-100: The effect of additives, *J Colloid Interf Sci* V-108 P-403 (1985)	2	54	56	1	3.57
P14	E.J. Land, T. Mukherjee, A.J. Swallow, J.M. Bruce.Reduction of naphthazarine molecule as studied by pulse radiolysis. Part I. Addition of a single electron, *J Chem Soc F1* V-79 P-391(1983)	27	28	55	0	49.09
P15	C. Manohar, U.R.K. Rao, B.S. Valaulikar, R.M. Iyer.On thc origin of viscoelasticity in micellar solutions of cetyl trimcthyl ammonium bromide and sodium salicylate, *J Chem Soc Chem Comm* P-379 (1986)	9	46	55	0	16.36
P16	R. Seshadri, C.N.R. Rao, H. Pal, T. Mukherjee, J.P. Mittal.Interaction C6ond C7o withromaticmines groundnd excited states. Evidence for fullerene -Benzeneteraction ground state, *Chem Phys Lett* V-205 P-395 (1993)	4	50	54	0	7.41
P17	N.J.F. Dodd, T. Mukherjee.Free radical formation from anthracycline antitumour agents and model systems I. Model naphthaquinones and anthraquinones, *Biochem Pharmacol* V-33 P-379 (1984)	10	43	53	0	18.87
P18	M.D. Sastry, A.G.I. Dalvi, Y. Babu, R.M. Kadam, J.V. Yakhmi, R.M. Iyer.Possible role of (CU+2-CU+4) pairs in the superconductivity of high-Tc YBa2Cu3O7-x : An EPR investigation, *Nature* V-330 P-49 (1987)	12	41	53	1	22.64
P19	Manohar Lal, C. Schoneich, J.Monig, K.D. Asmus.Rate constants for the reactions of halogenated organic radicals, *Int J Radiat Biol* V-54 P-773 (1988)	11	42	53	2	20.75
P20	K.I. Priyadarsini, Hari Mohan, A.K. Tyagi, J.P. Mittal.Inclusion complex' y-cycJodextrin-C6o : Formation, cnaracterisationnd photophysical propertiesqueous solutions, *J Phys Chem US* V-98 P-4756 (1994)	9	44	53	0	16.98
P21	N. Puglino, D.K. Palit, A.Z. Szarka, R.M. Hochstrasser. Wave packet dynamics HgI2 photodissociation reaction solution, *J Chem Phys* V-99 P- 7273 (1993)	16	36	52	1	30.77

(SC = Self-Citations; CO = Citations by others; TC = Total Citations; CTLY = Citation Time lag in Years; DR = Diachronous Self Citation Rate)

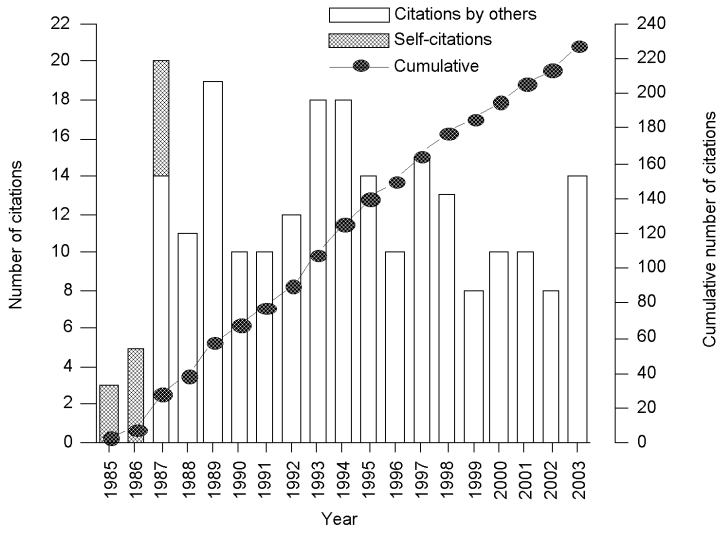

Figure 7a. Citation life cycle of paper P1: E. Konig, G. Ritter, S. K. Kulshreshtha. Nature of spin state transitions in solid Fe(II) complexes and its interpretation of some associated phenomena, *Chem Rev* V-85 P-219 (1985)

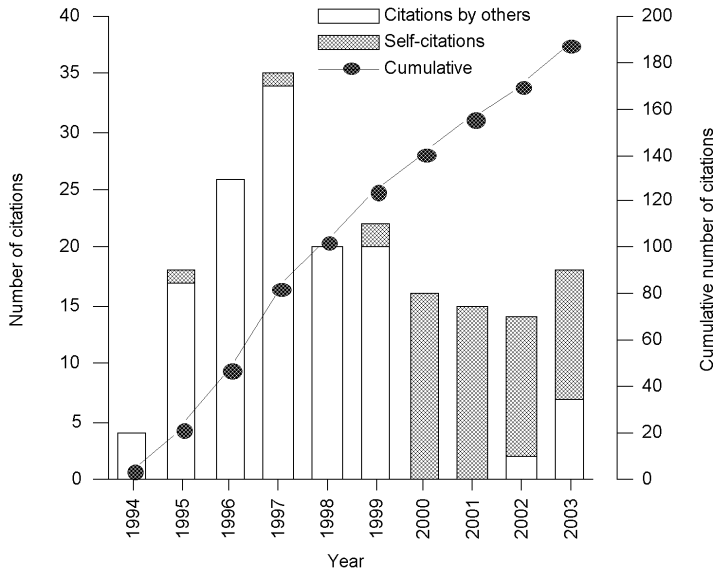

Figure 7b. Citation life cycle of paper P2: E. Fawcett, H. L. Alberts, V. Yu. Galkin, D. R. Noakes, J. V. Yakhmi. Spin-density wave antiferromagnetism in chromium alloys, *Rev Mod Phys* V-66 P-25 (1994)

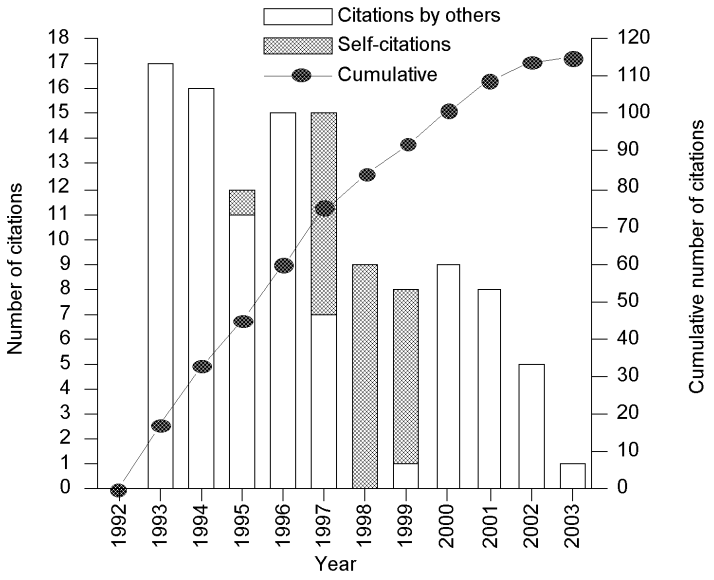

Figure 7c. Citation life cycle of paper P3: D. K. Palit, A. V. Sapre, J. P. Mittal, C. N. R. Rao. Photophysical properties of the fullerenes, C60 and C70, *Chem Phys Lett* V-195 P-1 (1992)

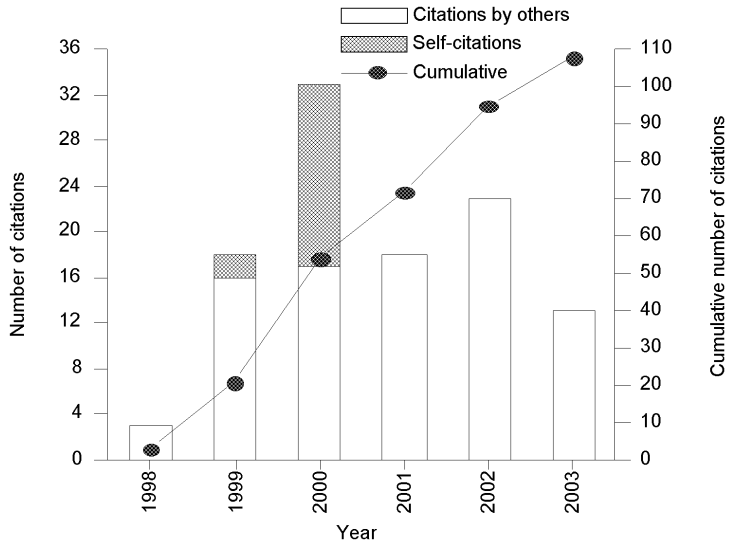

Figure 7d. Citation life cycle of paper P4: R. ElLingson, J. B. Asbury, S. Ferrere, H. N. Ghosh, T. Lian, A. J. Nozik. Dynamics of electron injection in nanocrystalline titanium dioxide films sensitized with [Ru(4, 4'-dicarboxy-2, 2-bipyridine)2(NCS)2] by infra-red transient absorption, *J Phys Chem B* V-102 P-6455 (1998)

Extent of citations and categories of citing documents

It is very important to know what is published where and what kind of communication channel is chosen for publication in order to gain visibility. A very qualitative paper published in an internationally well-known journal attracts the attention of the scientists instantly and receive many citations whereas an important paper published in an unknown journal may remain dormant and uncited for years.

Out of 1733 papers, 1556 (89.78%) papers were Journal Articles followed by 113 (6.52%) Technical Reports, 48 (2.77%) articles in Books, 5 (0.29%) Patents and 11 (0.64%) Others. The types of documents citing Chemistry Division publications is given in Figure 8. Among the citations received to the Chemistry Division Publications, 9737 (88.19%) were from Journal articles, followed by 933 (8.45%) from Reviews, 240 (2.17%) from Notes and 113 (1.02%) from Letters.

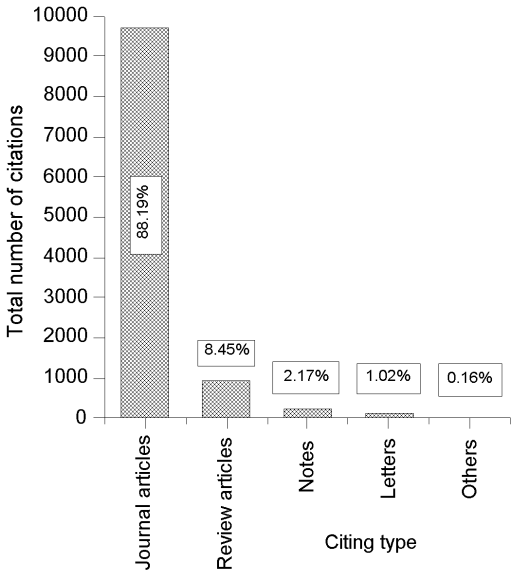

Figure 8. Types of documents citing Chemistry Division publications

Citing journals and their distribution

Out of 1556 papers 326 (21%) papers have been published in Indian journals which have received 544 citations, and 1230 (79%) papers in International journals which have received 10393 citations. There were 805 journals citing Chemistry Division publications. The leading citing journals were *Journal of Physical Chemistry–A* with

436 citations, *Chemical Physics Letters* with 372 citations, *Journal of Physical Chemistry* with 355 citations, *Journal of Chemical Physics* with 353 citations, *Journal of Organometallic Chemistry* with 285 citations, *Journal of Physical Chemistry–B* with 279 citations, *Journal of Photochemistry and Photobiology–A* with 263 citations, *Langmuir* with 245 citations, *Journal of the American Chemical Society* with 226 citations, *Physica–C* with 225 citations, *Radiation Physics and Chemistry* with 217 citations, Inorganic Chemistry with 215 citations and *Indian Journal of Chemistry–A* with 207 citations. Journal-wise scattering of citations is given in Table 6 and Bradford-Zipf citograph in Figure 9.

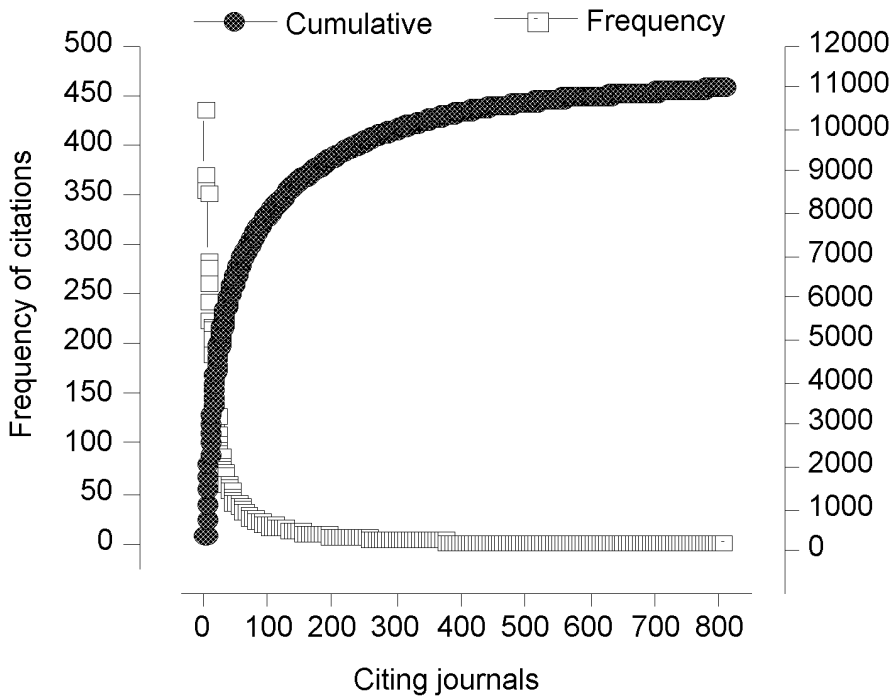

Figure 9. Bradford-Zipf citograph for Chemistry Division publications

Table 6. List of journals citing Chemistry Division publications

Sl. No.	Journal	IF 2003	Country	Citations	FCY-LCY	TCY
1.	J PHYS CHEM A	2.792	USA	436	1997–2003	7
2.	CHEM PHYS LETT	2.438	NETHERLANDS	372	1982–2003	22
3.	J PHYSICAL CHEMISTRY	–	USA	355	1982–1996	15
4.	J CHEM PHYS	2.95	USA	353	1982–2003	22
5.	J ORGANOMET CHEM	2.042	SWITZERLAND	285	1983–2003	21
6.	J PHYS CHEM B	3.679	USA	279	1997–2003	7
7.	J PHOTOCH PHOTOBIO A	1.693	SWITZERLAND	263	1987–2003	17
8.	LANGMUIR	3.098	USA	245	1988–2003	16
9.	J AM CHEM SOC	6.516	USA	226	1982–2003	22
10.	PHYSICA C	1.19	NETHERLANDS	225	1988–2001	14
11.	RADIAT PHYS CHEM	0.693	ENGLAND	217	1992–2003	12
12.	INORG CHEM	3.389	USA	215	1982–2003	22
13.	INDIAN J CHEM A	0.489	INDIA	207	1987–2003	17
14.	J CHEM SOC-FARA TRANS	–	ENGLAND	190	1990–1998	9
15.	POLYHEDRON	1.584	ENGLAND	170	1984–2003	20
16.	RADIATION PHYSICS AND CHEMISTRY-C	–	ENGLAND	169	1982–1991	10
17.	P INDIAN AS-CHEM SCI	0.649	INDIA	136	1982–2003	22
18.	RES CHEM INTERMEDIAT	0.645	NETHERLANDS	130	1995–2003	9
19.	J CHEM SOC PERK T 2	1.863	ENGLAND	129	1984–2002	19
20.	J CHEMICAL SOCIETY-DALT TRANS	–	ENGLAND	113	1982–2002	21
21.	J COLLOID INTERF SCI	1.582	USA	110	1983–2003	21
22.	PHYSICAL REVIEW B	–	USA	102	1982–1999	18
23.	COORDIN CHEM REV	5.951	SWITZERLAND	94	1983–2003	21
24.	SOLID STATE COMMUN	1.602	ENGLAND	92	1982–2003	22
25.	J NUCL MATER	1.179	NETHERLANDS	90	1982–2003	22
26.	PHYS CHEM CHEM PHYS	1.959	ENGLAND	89	1999–2003	5
27.	COLLOID SURFACE A	1.44	NETHERLANDS	80	1993–2003	11
28.	J APPL POLYM SCI	1.017	USA	80	1982–2003	22
29.	B CHEM SOC JPN	1.237	JAPAN	75	1984–2003	20
30.	J CATAL	3.276	USA	74	1982–2002	21
31.	J PHYS-CONDENS MAT	1.757	ENGLAND	73	1989–2003	15
32.	INORG CHIM ACTA	1.578	SWITZERLAND	72	1986–2003	18
33.	PHOTOCHEM PHOTOBIOL	1.929	USA	71	1982–2003	22
34.	THERMOCHIM ACTA	0.956	NETHERLANDS	61	1982–2003	22
35.	CHEM PHYS	2.07	NETHERLANDS	60	1983–2003	21
36.	TRANSIT METAL CHEM	0.84	NETHERLANDS	60	1984–2003	20
37.	CHEM REV	21.036	USA	58	1982–2003	22
38.	PHYSICA B	–	NETHERLANDS	58	1990–2001	12
39.	J ALLOY COMPD	1.08	SWITZERLAND	55	1992–1996	5

Table 6. cont.

Sl. No.	Journal	IF 2003	Country	Citations	FCY-LCY	TCY
40.	J APPL PHYS	2.171	USA	55	1982–2003	22
41.	ORGANOMETALLICS	3.375	USA	55	1987–2003	17
42.	J MAGN MAGN MATER	0.91	NETHERLANDS	48	1984–2003	20
43.	CHEM MATER	4.374	USA	47	1993–2003	11
44.	INT J CHEM KINET	1.376	USA	44	1982–2003	22
45.	PHYS STATUS SOLIDI A	0.95	GERMANY	43	1982–2001	20
46.	SUPERCOND SCI TECH	2.247	ENGLAND	43	1988–2002	15
47.	J RADIOANA NUCL CHEM-ART	–	NETHERLANDS	43	1986–1996	11
48.	CURR SCI INDIA	0.694	INDIA	42	1982–2003	22
49.	INDIAN J CHEM B	0.492	INDIA	42	1982–1987	6
50.	J MATER SCI	0.826	NETHERLANDS	42	1982–2003	22
51.	MATER RES BULL	1.144	ENGLAND	42	1984–2003	20
52.	J ORG CHEM	3.297	USA	41	1984–2003	20
53.	PHOSPHORUS SULFUR	0.323	ENGLAND	40	1989–2003	15
						truncated

FCY = First Citations Year; LCY = Last Citations Year; TCY = Total Citations/Year

Distribution of citing journals according to Impact Factors

The dynamics and internal structure of the system of scientific communication are greatly influenced by varying quality of the primary journals in which scientific communications are published. The analysis of citations is one of the means by which policy makers, scientists and librarians seek to achieve a greater understanding of the qualitative forces that affect formal communications in science. The higher indices of "immediacy" tend to produce higher measures of "impact" and the eminence of the journals is determined mainly by the impact factor.

More than 75 percent of the citations received were published from journals with impact factors ranging from 0.01 to 31.0 indicates the quality of Chemistry Division publications. Only 22.73 percent of the citing journals had no impact factors. The distribution of citing journals as per impact factors is given in Table 7.

Country distribution of citing journals

Table 8 gives the country distribution of citing journals and number of citations. Among the top ranking journals citing Chemistry Division publications are from USA with 4026 (36.46%) followed by England with 2463 (22.31%) citations, The Netherlands with 1895 (17.16%) citations, Switzerland with 936 (8.48%) citations, India with 476 (4.31%) and Germany with 458 (4.15%) citations.

Table 7. Distribution of citations by the Impact Factor of the citing journals

Impact Factor range	Number of citing journals	Number of citations
n/a	183	1987
0.01–0.5	74	740
0.51–1.0	124	1438
>1.00–2.00	204	2666
>2.00–3.00	105	2324
>3.00–4.00	50	1066
>4.00–5.00	21	194
>5.00–6.00	11	169
>6.00–10.00	20	345
>10.00–20.00	8	33
>20.00–31.00	5	79
Total	805	11041

Distribution of keywords in the citing papers

Keywords are one of the best scientometric indicators to understand and grasp instantaneously the thought content of the papers and to find out the growth of the subject field. By analyzing the keywords appeared either on the title or assigned by the indexer or the author himself will help in knowing in which direction the knowledge grows. The high frequency keywords will enable us to understand what are all the aspects of chemistry have been studied. The keywords appeared in the Key Words Plus field in SCI of citing papers were analysed to assess the impact of the Chemistry Division publications to the wide ranging domains of chemistry. The high frequency keywords were Aqueous solutions (779), Pulse radiolysis (775), Crystal structures (514), Chemistry (489), C-60 (466), Molecular structures (454), System (441), and Rate constants (432). Table 9 gives a list of high frequency keywords appeared more than 90 times.

Table 8. Country distribution of citing journals

Rank	Citing country	Number of citations	%
1	USA	4026	36.46
2	ENGLAND	2463	22.31
3	NETHERLANDS	1895	17.16
4	SWITZERLAND	936	8.48
5	INDIA	476	4.31
6	GERMANY	458	4.15
7	JAPAN	169	1.53
8	RUSSIA	159	1.44
9	FRANCE	74	0.67
10	CANADA	43	0.39
11	DENMARK	37	0.34
12	PEOPLESRCHINA	36	0.33
13	IRELAND	31	0.28
14	SINGAPORE	30	0.27
15	AUSTRALIA	29	0.26
16	POLAND	18	0.16
17	AUSTRIA	16	0.14
17	HUNGARY	16	0.14
18	TAIWAN	14	0.13
19	CZECHREPUBLIC	12	0.11
19	USSR	12	0.11
20	ISRAEL	11	0.10
21	SOUTH KOREA	10	0.09
22	LATVIA	9	0.08
23	ITALy	8	0.07
23	LAUSANNE	8	0.07
24	GREECE	7	0.06
24	UAE	7	0.06
25	BRAZIL	5	0.05
26	BELGIUM	4	0.04
26	ROMANIA	4	0.04
26	UKRAINE	4	0.04
27	SLOVAKIA	3	0.03
28	COLOMBIA	2	0.02
28	CROATIA	2	0.02
28	PAKISTAN	2	0.02
29	BELARUS	1	0.01
29	SOUTH AFRIKA	1	0.01
29	SPAIN	1	0.01
29	SWEDEN	1	0.01
29	THAILAND	1	0.01
Total		11041	100.00

Table 9. Keywords and their frequencies ≥ 90 appeared in citing papers in the Keywords Plus field as per SCI (1982–2003)

Keywords	Frequency	Keywords	Frequency
AQUEOUS-SOLUTIONS	779	DIMERS	153
PULSE-RADIOLYSIS	775	TITANIUM-DIOXIDE FILMS	151
CRYSTAL-STRUCTURES	514	STABILITY	147
CHEMISTRY	489	BUCKMINSTERFULLERENE	142
C-60	466	BENZENES	140
MOLECULAR-STRUCTURES	454	PHOTOINDUCED ELECTRON-TRANSFER	140
SYSTEM	441	MOLECULES	138
RATE CONSTANTS	432	ELECTRON-TRANSFER REACTIONS	135
OXIDATION	381	PHOTOCHEMISTRY	135
REDUCTION	381	SOLVENT	126
COMPLEXES	337	CHARGE-TRANSFER	125
STATE	337	PHOTOLYSIS	125
LIGANDS	316	SURFACE	119
SPECTROSCOPY	305	X-RAY	119
C-70	302	SCATTERING	118
DERIVATIVES	296	ENERGIES	112
RAY CRYSTAL-STRUCTURES	289	ANGLE NEUTRON-SCATTERING	111
LASER FLASH-PHOTOLYSIS	284	POTENTIAL-ENERGY SURFACES	110
WATER	283	CETYLTRIMETHYLAMMONIUM BROMIDE	109
DYNAMICS	271	DEPENDENCES Count	109
SPECTRA	267	HYDROGENATION	108
PHOTOPHYSICAL PROPERTIES	262	NUCLEAR-MAGNETIC-RESONANCE	106
MECHANISMS	258	THIN-FILMS	106
FLUORESCENCE	255	TRANSIENT ABSORPTION	106
REACTIVITY	230	CHARGE-TRANSFER COMPLEXES	105
FULLERENES	228	METALS	104
RADICALS	224	ORGANOTIN CARBOXYLATES	103
ACIDS	220	MOSSBAUER EMISSION-SPECTROSCOPY	101
TEMPERATURE	216	PHOTODISSOCIATION	101
TRANSITION	215	TRIPLET-STATES	100
KINETICS	212	CARBON-MONOXIDE	99
BEHAVIOR	193	MIXTURES	98
ELECTRON-TRANSFER	187	HYDROXYL RADICALS	96
ABSORPTION	185	BONDS	95
METAL-COMPLEXES	183	OH RADICALS	95
OXYGEN	180	SINGLE-CRYSTALS	95
MODELS	179	FILMS	94
ONE-ELECTRON-REDUCTION	179	RELAXATION	94
ELECTRON-SPIN-RESONANCE	177	ABSORPTION-SPECTRA	92
ADSORPTION	174	CATALYTIC ACTIVITY	92
CRYSTALS	174	ELECTRONS	92
CATIONS	168	HIGH-TC SUPERCONDUCTORS	92
IONS	167	ANTHRAQUINONES	91
PHASE	161	SOLVATION DYNAMICS	91
EXCITED-STATES	159	CU-O SYSTEM	90
OXIDES	155		

Conclusion

This paper attempted to highlight the impact of research carried out by the scientists of Chemistry Division at Bhabha Atomic Research Centre during 1970–1999.The Division has published 1733 publications during this period in diverse domains. The citation analysis of these publications is carried out covering the period 1982–2003 using Science Citation Index. The publications published 1970–1981 were also included for the analysis. The results indicate that 92.46 percent of the cited papers have received their first citations within five years of their publication shows that Chemistry Division publications were noticed immediately by the researchers working all over the world in this field and well integrated in the evolving research front. During 1982–2003 Chemistry Division publications have received a total of 11041 citations. The highest number of citations received were 877 in 2001. The average number of citations per year was 500.64 and the average number of citations per publications was 6.37. The self citations were 3716 (33.66%) and citations by others were 7325 (66.34%). The diachronous self-citation rate was 36.16. There were 805 journals spread across 41 countries covering many multidisciplinary areas of research have cited Chemistry Division publications indicates their influence and impact over many allied areas of research. As many as twenty one highly cited publications could be identified based on the number of citations they have received. It will be quite interesting if one attempts to study the motivations for which Chemistry Division publications received citations.

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