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SCIENTOMETRIC DIMENSIONS OF INNOVATION COMMUNICATION PRODUCTIVITY OF THE CHEMISTRY DIVISION AT BHABHA ATOMIC RESEARCH CENTRE

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ABSTRACT

Scientrometric analysis of 1733 papers published by the teams comprising total of 926 participating scientists at Chemistry Division of Bhabha Atomic Research Centre (BARC) during 1970-1999 in the domains: Radiation & Photochemistry and Chemical Dynamics (649), Solid State Studies (558), Inorganic, Structural and Materials Chemistry (460) and Theoretical Chemistry (66) were analysed for yearwise productivity, authorship pattern and collaboration. The highest number of publications in a year were 98 and 104 produced in 1989 and 1996 respectively. The average number of publications per year was 57.76. The highest collaboration coefficient 1.0 was in 1977 and 1999. The authors with most prolific publications were J. P. Mittal (204), R. M. Iyer (190), J. V. Yakhmi (156), V. K. Jain (106), Hari Mohan (96), K. N. Rao (92), I. K. Gopalakrishnan (80), P. N. Moorthy (78), T. Mukherjee (77), and S. K. Kulshreshtha (74). The core journals preferred for publishing with high number of publications were: Indian Journal of chemistry - A (96), Radiation Physics and Chemistry (92), Chemical Physics Letters (67), Journal of Physical Chemistry (59) and Indian Journal of Chemistry (45). Publication concentration was 28.57% and publication density was 5.48. Top ranking journals publishing chemistry division BARC publications were from UK (471), India (326), The Netherlands (302), USA (277) and Switzerland (104).

Keywords: Scientometrics; Bibliometrics; Individual division; Individual department; Individual institution; R & D laboratory; Publication productivity; Authorship pattern; Collaboration Coefficient; Channels of communication; BARC; Chemistry Division; Lotka's Law ; Bradford distributon.

INTRODUCTION

Evaluating the productivity of an institutional research and development activities highlights the contribution of the institution and the individual scientists engaged in research. It also provides some insights into the complex dynamics of research activity and enables policy makers and administrators to provide adequate facilities and gauge the research activities in a proper direction. A well known productivity indicator is the number of publications produced by scientists, institutions, or research groups. Over the years, scientometric and bibliometric techniques have become tools to evaluate the productivity of research institutes and individual researcher, as well as to map the growth of the research area. The term "Naukometriya" (the Russian for "Scientometrics") was coined by a Russian statistician, Nalimov (1966), for the quantitative methods of studying the development of science. Pritchard (1969) described bibiliometrics as "the applications of mathematical methods to books and other media of communication". Narin (1976) used the term "Evaluative bibliometrics" to denote the use of bibliometric techniques, especially publication and citation analysis in the assessment of a scientific activity.

Publication and citation counts are being extensively used for evaluation purpose of an institute (Salisbury, 1980; Cohen, 1981; Shubert and Braun, 1981; Yankevich, 1982; Carpenter, Gibb, Harris, Irvin, Martin,and Narin 1988; Garg and Rao, 1988; Vinkler, 1990; Minor and Dostatni, 1991; Kalyane and Vidysagar Rao, 1992; Dizon and Sadorra, 1995; Ugolini, Parodi and Santi, 1997; King, 1998; Gupta, Suresh Kumar and Khanna, 1999; Kalyane and Kalyane, 1991, 1994, 1996; Zachos, 1991; Frohlic and Resler, 2001; Koganuramath, Angadi and Kademani, 2002; Swarna, Kalyane and Vijai Kumar 2002; Lee, 2003; Schloegl, Gorraiz, Bart and Bargmann, 2003). Many studies have also been conducted to evaluate the productivity of 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 chemists from the Rugjer Bošković Institute in Yugoslavia, using both publications and citation counts. Adopting similar method, Kim and Kim (2000) examined research performance of chemists, analysing a total of 651 papers published by the 29 faculty members at the Chemistry Department, Seoul National University, Korea, from 1992-1998. Bishop, Gillet, Holliday and Willet (2003) reviewed the work of the Chemoinformatics Research Group at the Department of Information Studies, University of Sheffield during 1985-2002. The study also carried out a citation analysis of 321 papers published during 1980-2002.

Chemistry and chemical technology are deeply interwoven into the fabric of any country's atomic energy programme. The Department of Atomic Energy (DAE) was formally constituted on August 3, 1954 with headquarters in Mumbai, and the Chemistry Division became one of the first Scientific Divisions in the department. Since 1960, the Chemistry Division had been streamlined and research activities were focused in the areas of Radiation & Photochemistry and Chemical Dynamics; Solid state studies; Inorganic, structural and materials chemistry; and Theoretical chemistry. On February 5, 1999 the Chemistry Division was bifurcated into Radiation Chemistry & Chemical Dynamics Division, and Novel Materials & Structural Chemistry Division to provide more impetus to the modern thrust areas in the atomic energy programmes. Venkateswarlu and George (1998) have given a detailed descriptive account of chemistry research in atomic energy programmes in India.

OBJECTIVES

The main objective of the study is to quantitatively document the publication productivity behaviour of Chemistry Division scientists at Bhabha Atomic Research Centre (BARC). Specifically this involves:

a) finding out yearwise publication productivity,
b) documenting domainwise publications productivity,
c) documenting domainwise authorship and collaboration pattern,
d) identifying the authors having most prolific publications,
e) verifying Lotka's Law of author productivity,
f) identifying the types of communication channels preferred,
g) verifying Bradford's Law for distribution of papers and sources,
h) finding out the countrywise distribution of journals, and
i) documenting high frequency keywords from titles of the papers.

MATERIALS AND METHODS

A total of 1733 publications, published by the scientists of Chemistry Division at Bhabha Atomic Research Centre during 1970-1999 (Sapre and Kesavdas,1998; Kalyane ,1999) formed the basic data for this study. All the bibliographic details of publications in hardcopy form were scanned and all the data elements were transferred to a spreadsheet application. After validation, the data was analysed as per the requirement of the study. The bibliographic data was analysed by normal count procedure (Kalyane and Vidyasagar Rao K, 1995)

RESULTS AND DISCUSSION

Yearwise growth of publications

During 30 years period (1970-1999) Chemistry Division at BARC has produced a total of 1733 publications. Figure 1 and Table 1 present the yearwise publication productivity, authorship pattern, collaboration trend among scientists and cumulative growth of publications. The average number of publications per year was 57.8 with the highest being 104 in 1996. About 90.3% of publications were multi-authored and only 9.7% single-authored. The highest collaboration coefficient (number of collaborative papers divided by total number of papers) was found in 1977 and 1999.

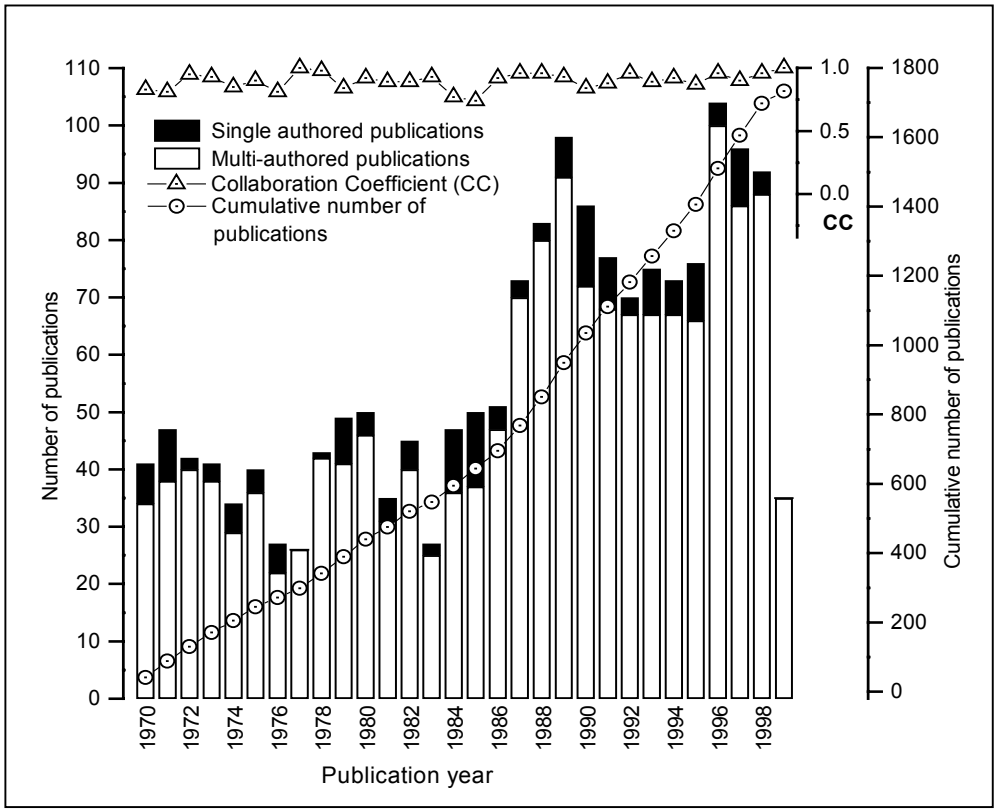

Figure 1: Chronological publication productivity trend at BARC

Table 1: Yearwise productivity and collaboration coefficient in the publications

Year	Single authored papers	Multi-authored papers	Total	Collaboration Coefficient
1970	7	34	41	0.83
1971	9	38	47	0.81
1972	2	40	42	0.95
1973	3	38	41	0.93
1974	5	29	34	0.85
1975	4	35	39	0.90
1976	5	23	28	0.82
1977	0	26	26	1.00
1978	1	42	43	0.98
1979	8	41	49	0.84
1980	4	46	50	0.92
1981	4	31	35	0.89
1982	5	40	45	0.89
1983	2	25	27	0.93
1984	11	36	47	0.77
1985	13	37	50	0.74
1986	4	47	51	0.92
1987	3	70	73	0.96
1988	3	80	83	0.96
1989	7	91	98	0.93
1990	14	72	86	0.84
1991	9	68	77	0.88
1992	3	67	70	0.96
1993	8	67	75	0.89
1994	6	67	73	0.92
1995	10	66	76	0.87
1996	4	100	104	0.96
1997	10	86	96	0.90
1998	4	89	93	0.96
1999	0	34	34	1.00
Total	168	1565	1733	0.90

Domainwise Contributions

During three decades (1970 – 1999) Chemistry Division at BARC has contributed significantly to the following main domains and sub-domains:

A – Radiation & Photochemistry and Chemical Dynamics

B – Solid state studies (Sub-domains: Interfacial Chemistry and Catalysis; High Temperature Superconductors; Molecular magnets; Magnetic materials, Clusters; High Pressure Studies; High Tech Materials High Pressure Studies; Vapour Phase Deposition; Radiation Damage studies, Cold Fusion, Metal Hydrides; Thermal Properties; Transport Properties.

C – Inorganic, Structural and Materials Chemistry (Sub-domains: Synthetic and Structural Chemistry; Materials Science; Inorganic and Structural Chemistry)

D – Theoretical Chemistry

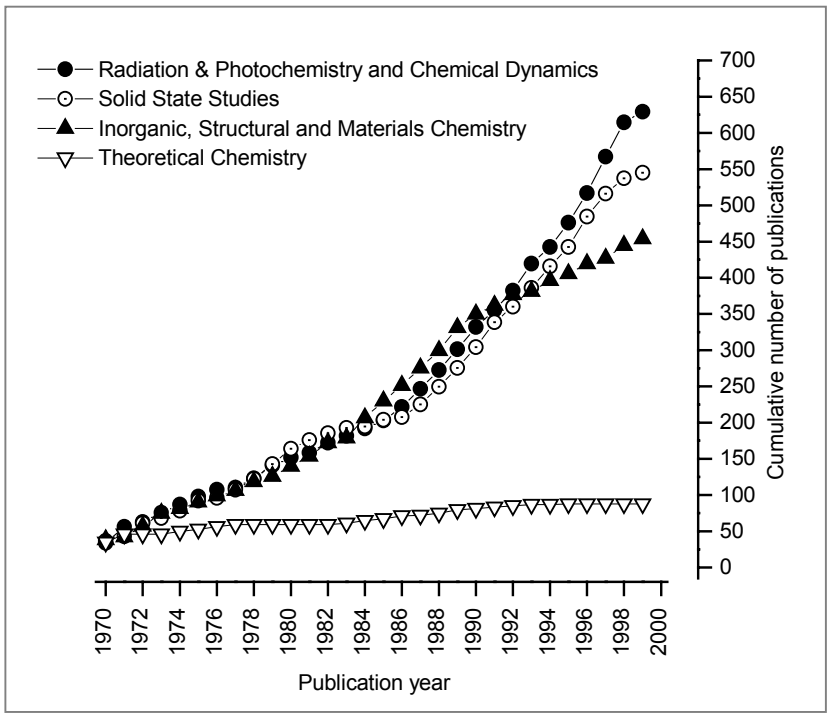

Figure 2: Domainwise growth of publications of Chemistry Division at BARC

There were 649 publications in Radiation & Photochemistry and Chemical Dynamics followed by 558 in Solid State Studies, 460 in Inorganic, Structural and Material Chemistry, and 66 in Theoretical Chemistry. The domainwise annual growth of publications is presented in Figure 2. The highest number of publications in Radiation & Photochemistry and Chemical Dynamics were 54 in 1997 and 51 in 1998, followed by 45 and 37 publications in Solid State Studies in 1996 and 1991 respectively, 34 and 30 publications in Inorganic, Structural and Material Chemistry in 1989 and 1984, and 12 and 9 publications in Theoretical Chemistry in 1971 and 1970 respectively. It is interesting to note that no paper was published during 1978-1982, 1994 and 1996-1999 in the Theoretical Chemistry domain.

a) Domainwise Collaboration Pattern

Yearwise growth of publications, collaboration trend in each domain are presented in Figures 3a, 3b, 3c, and 3d. To measure the collaborative research pattern a simple indicator called collaboration coefficient (number of collaborative papers divided by total number of papers) is used. Highest collaboration-coefficient was found during 1972-1973, 1977-1979, 1981, 1983, 1986 and 1999 in domain Radiation & Photochemistry and Chemical Dynamics; Solid State Studies domain in 1977, 1987, 1988, and 1999; Inorganic, Structural and Materials Chemistry domain during 1976-1978, 1983, 1991,1992,1998-1999; and Theoretical Chemistry domain during 1974, 1975, 1977, 1983, 1986-1988, 1990, 1992 and 1993.

b) Domainwise Authorship Pattern

The domainwise authorship pattern and the number of publications in each domain are presented in Table 2. The authorship trend is towards multi-authored papers. Two authored papers account for 28.45% followed by three-authored papers 27.99% and four authored papers 15.46%. There is a similar trend in all the domains i.e. more number of papers are two, three and four authored papers. There are as many as thirteen authored papers which indicate the multidisciplinary nature of research activity.

Twentieth century has seen a tremendous collaborative research among scientists working in groups within and across the geographic boundaries of a country, which enhanced the ability of scientists to put in their intellect collectively and make significant progress in their respective domains of specialization. Collaboration is inevitable in natural sciences and multidisciplinary areas to make significant advances and breakthrough (Macrina, 2000).

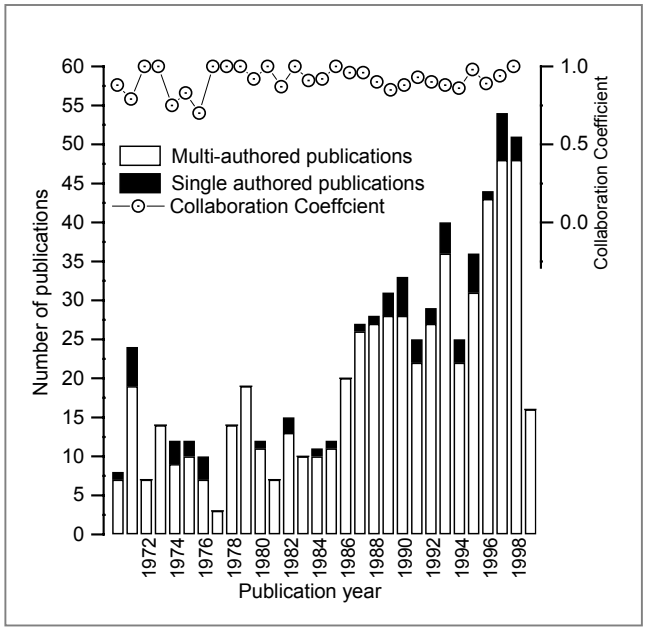

Figure 3a: Publication trend in Radiation & Photochemistry and Chemical Dynamics

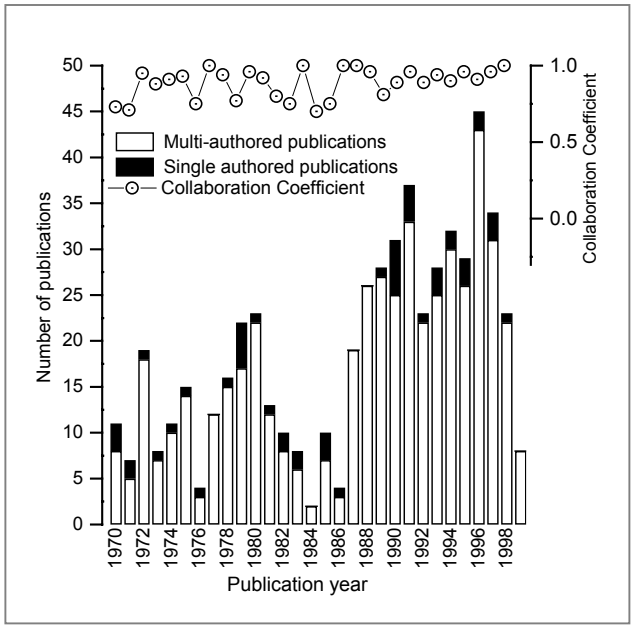

Figure 3b: Publication trend in Solid State Studies

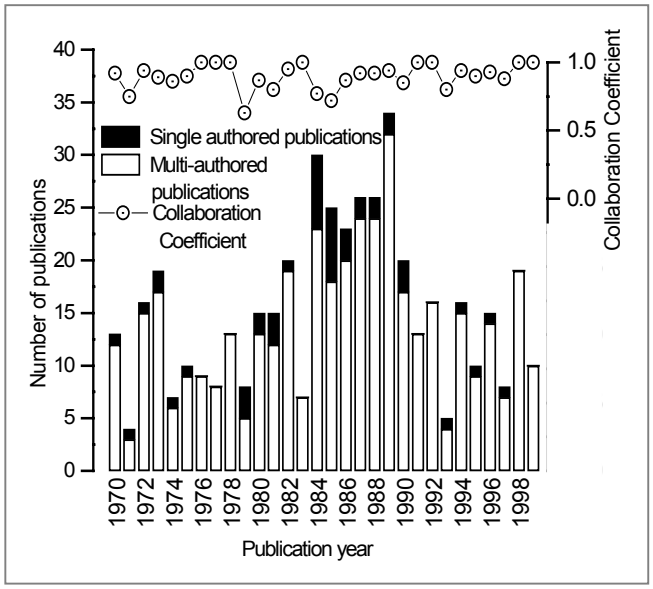

Figure 3c: Publication trend in Inorganic, Structural and Materials Chemistry

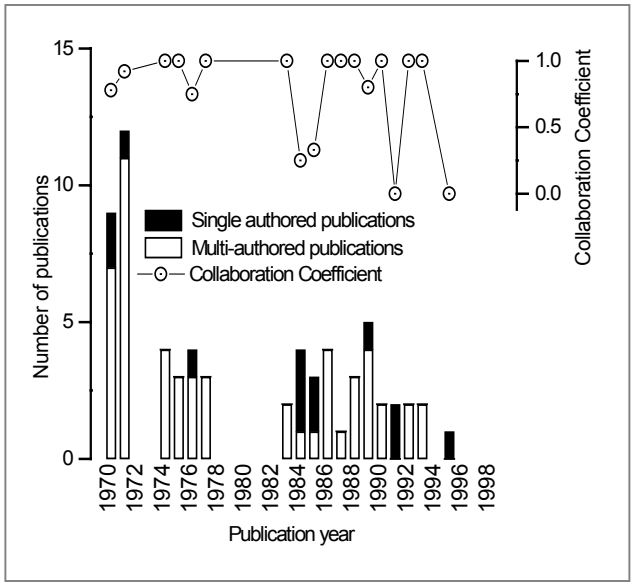

Figure 3d: Publication trend in Theoretical Chemistry

Table 2: No. of papers having domainwise authorship pattern in the publications of Chemistry Division at BARC during 1970-1999

Authorships	Domains				Total Number of papers	Percentage
	A	**B**	**C**	**D**		
One	56	52	47	13	168	9.69
Two	173	134	161	25	493	28.45
Three	193	139	140	13	485	27.99
Four	111	81	69	7	268	15.46
Five	69	70	23	5	167	9.64
Six	25	40	14	0	79	4.56
Seven	11	20	4	1	36	2.08
Eight	8	12	1	0	21	1.21
Nine	2	6	0	0	8	0.46
Ten	0	1	1	1	3	0.17
Eleven	1	2	0	0	3	0.17
Twelve	0	0	0	1	1	0.06
Thirteen	0	1	0	0	1	0.06
Total	649	558	460	66	1733	100.00

A-Radiation & Photochemistry and Chemical Dynamics; **B**-Solid State Studies; **C**-Inorganic, Structural and Materials Chemistry; and **D**-Theoretical Chemistry

Price (1965) studied the collaboration phenomenon in chemistry publications published during 1910-1960, as reflected in the increase in multi-authored publications in Chemical Abstract database. Gupta and Karisiddappa (2000) listed several studies conducted in various disciplines, which show a trend towards multiauthorship papers.

Chronological Occurrence of Authors and Their Productivity

Researchers and their authorships as per the author serial number in the chronological order of occurrence (starting with first publication year) are depicted in Figure- 4. From this figure one can easily visualize the productivity of scientists in terms of their authorships at their association for the first paper with the Division .The Chemistry

Division had 926 scientists producing 1733 papers with 5570 authorships during the period under study.

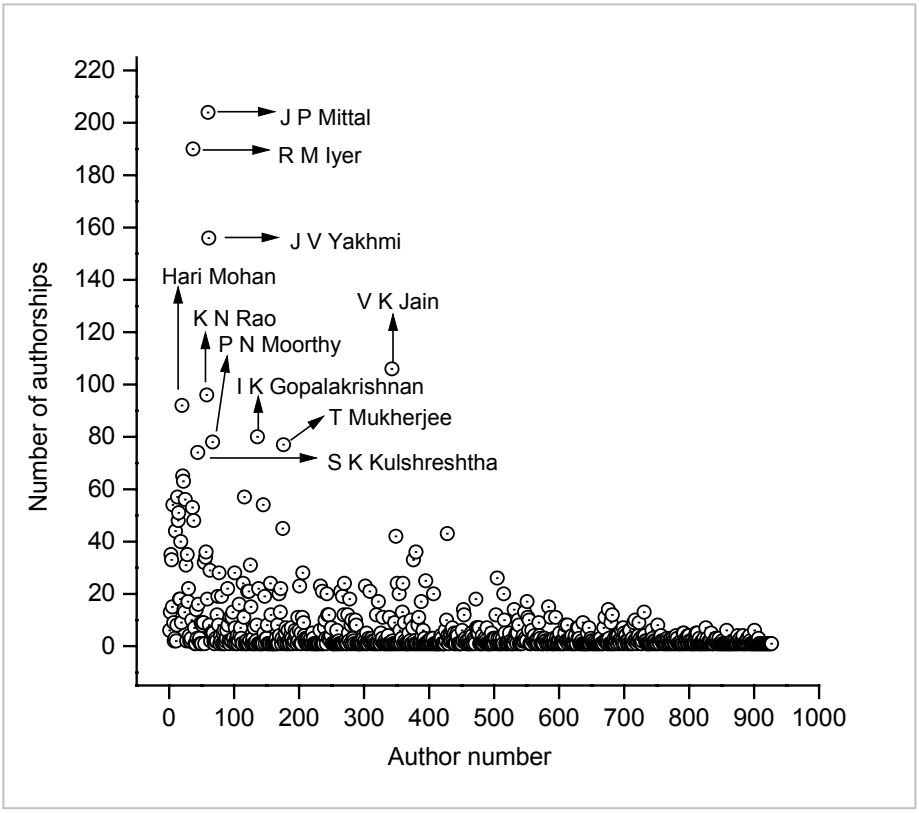

Figure 4: Authorship profile of scientists of Chemistry Division at BARC depicting their association as per occurrence of name in the byline of first paper by each one (Author number) during 1970-1999

Most Prolific Authors

The Most prolific authors were J P Mittal (1971-1999) who topped the list with 204 papers during the period under study followed by R M Iyer (1970-1998) with 190 publications, J V Yakhmi (1971-1999) with 156 publications, V K Jain (1985-1999) with 106 publications, Hari Mohan (1971-1999) with 96 publications, K N Rao (1970-1996) with 92 publications, I K Gopalakrishnan (1974-1999) with 80 publications, P N Moorthy (1971-1995) with 78 publications, T Mukherjee (1976-1999) with 77

publications and S K Kulshreshtha (1970-1998) with 74 publications. Figure 5 presents the details of ten highly prolific authors, and Table 3 provides a list of 34 out of 926 authors who have contributed at least 32 papers each.

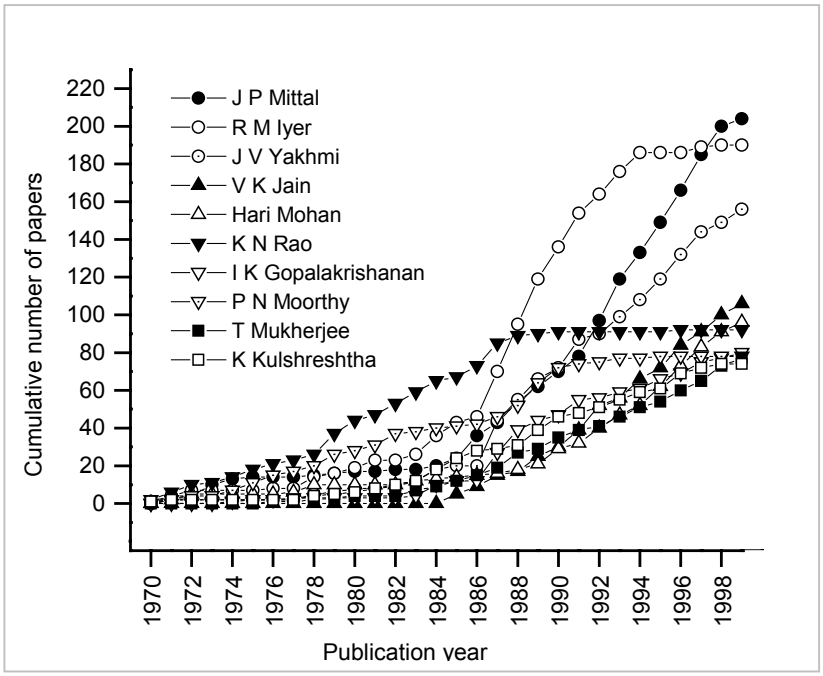

Table 3: Authorship Credits during First Paper Year and Last Paper Year and Authorships Per Year in Publications (1970-1999) at BARC

Author	Domainwise no. of authorships				No. of authorships	Period of association FPY-LPY	TY	APY
	A	B	C	D				
J P Mittal	200	0	2	2	204	1971-1999	29	7.03
R M Iyer	37	128	23	2	190	1970-1998	29	6.55
J V Yakhmi	0	137	17	2	156	1971-1999	29	5.38
V K Jain	0	2	104	0	106	1985-1999	15	7.07
Hari Mohan	91	2	1	2	96	1971-1999	29	3.31
K N Rao	82	2	1	7	92	1970-1996	27	3.41

I K Gopalakrishnan	0	69	11	0	80	1974-1999	26	3.08
P N Moorthy	71	2	1	4	78	1971-1995	25	3.12
T Mukherjee	75	1	0	1	77	1976-1999	24	3.21
S K Kulshreshtha	6	37	31	0	74	1970-1998	29	2.55
K S Venkateswarlu	6	3	44	12	65	1970-1999	30	2.17
K V S Rama Rao	55	2	3	3	63	1970-1996	27	2.33
N M Gupta	1	53	2	1	57	1973-1999	27	2.11
C Manohar	1	55	0	1	57	1970-1998	29	1.97
M D Karkhanavala	8	39	3	6	56	1970-1981	12	4.67
C Gopinathan	47	1	1	5	54	1975-1999	25	2.16
A R Gupta	0	15	37	2	54	1970-1995	26	2.08
P Raj	1	34	17	1	53	1970-1999	30	1.77
G S Rao	0	0	50	1	51	1970-1998	29	1.76
R P Agarwala	1	27	16	4	48	1970-1997	28	1.71
G M Phatak	1	31	16	0	48	1970-1998	29	1.66
S N Vaidya	0	28	15	2	45	1976-1997	22	2.05
A V Sapre	42	0	1	1	44	1970-1998	29	1.52
P V P S S Sastry	0	43	0	0	43	1988-1998	11	3.91
D K Palit	42	0	0	0	42	1986-1998	13	3.23
J Shankar	13	2	25	0	40	1970-1980	11	3.64
K I Priyadarsini	35	0	0	1	36	1987-1999	13	2.77
B Vankataramani	1	17	16	2	36	1971-1998	28	1.29
M S Anand	1	25	7	2	35	1970-1997	28	1.25
A K Dua	0	24	9	2	35	1970-1999	30	1.17
B M Pande	3	24	6	1	34	1971-1998	28	1.21
H Pal	32	0	1	0	33	1987-1998	12	2.75
A M George	1	23	9	0	33	1970-1999	30	1.10
A Sathyamoorthy	0	16	14	2	32	1971-1999	29	1.10
M H Rao	29	0	0	2	31	1970-1996	27	1.15
S N Guha	25	1	3	2	31	1973-1999	27	1.15
K Kishore	24	1	3	1	29	1971-1995	25	1.16
V S Kamble	1	27	0	0	28	1978-1999	22	1.27
A J Singh	1	3	22	2	28	1973-1995	23	1.22
V K Kelkar	6	22	0	0	28	1971-1993	23	1.22
R K Vatsa	25	1	0	0	26	1990-1997	8	3.25
A Sequeira	0	25	0	0	25	1988-1996	9	2.78
J T Kunjappu	8	12	0	4	24	1986-1993	8	3.00
S Kapoor	24	0	0	0	24	1986-1999	14	1.71
S K Sarkar	23	0	0	1	24	1982-1998	17	1.41
L C Gupta	0	17	7	0	24	1973-1994	22	1.09
M D Sastry	0	22	2	0	24	1975-1999	25	0.96
T K Das	0	0	21	2	23	1971-1995	25	0.92
L C T Shoute	23	0	0	0	23	1984-1996	13	1.77
P Suryanarayana	0	11	10	2	23	1980-1994	15	1.53

M S Sastry	2	1	20	0	23	1978-1998	21	1.10
M S Chandrasekharaiah	0	20	0	2	22	1972-1983	12	1.83
K A Rao	10	5	3	4	22	1976-1998	23	0.96
Manohar Lal	22	0	0	0	22	1970-1992	23	0.96
K Gangadharan	0	12	10	0	22	1974-1998	25	0.88
P K Chowdhury	21	0	0	0	21	1984-1998	15	1.40
P K Bhattacharyya	20	0	1	0	21	1982-1997	16	1.31
R P Patel	3	0	17	1	21	1980-1998	19	1.11
S C Jain	0	1	20	0	21	1973-1991	19	1.11
R Vijayaraghavan	0	16	5	0	21	1973-1994	22	0.95
Awadhesh Kumar	20	0	0	0	20	1991-1998	8	2.50
H Rajagopal	0	20	0	0	20	1988-1996	9	2.22
P D Naik	19	0	0	1	20	1986-1997	12	1.67
C G S Pillai	0	14	6	0	20	1981-1998	18	1.11
V C George	0	14	5	1	20	1975-1996	22	0.91
R D Saini	15	2	1	1	19	1982-1999	18	1.06
D D Pruthi	0	15	4	0	19	1975-1996	22	0.86
Deoki Nandan	0	7	12	0	19	1972-1994	23	0.83
U R K Rao	0	16	1	2	19	1971-1996	26	0.73
P Neta	18	0	0	0	18	1989-1998	10	1.80
H S Ahuja	0	1	17	0	18	1970-1986	17	1.06
V Parthasarathy	17	0	0	1	18	1982-1998	17	1.06
J M Luthra	0	14	3	1	18	1971-1992	22	0.82
H S Mahal	9	1	5	3	18	1970-1999	30	0.60
H N Ghosh	17	0	0	0	17	1992-1999	8	2.13
R M Kadam	0	17	0	0	17	1987-1999	13	1.31
E R T Tiekink	0	0	17	0	17	1985-1999	15	1.13
M S Gill	0	2	15	0	17	1970-1996	27	0.63
E Hayon	16	0	0	0	16	1973-1977	5	3.20
S K Sarpal	0	4	11	1	16	1970-1991	22	0.73
H R Volpp	15	0	0	0	15	1993-1998	6	2.50
A P G Kutty	1	6	7	1	15	1970-1993	24	0.63
S S Gupta	0	0	15	0	15	1973-1998	26	0.58
S A Chavan	0	14	0	0	14	1995-1999	5	2.80
S Kannan	0	0	14	0	14	1991-1996	6	2.33
B A Dasannacharyya	0	14	0	0	14	1989-1998	10	1.40
S B Srivastava	12	0	1	1	14	1970-1989	20	0.70
L V Shastri	14	0	0	0	14	1970-1998	29	0.48
R A Brownsword	13	0	0	0	13	1996-1998	3	4.33
D K Maity	13	0	0	0	13	1992-1999	8	1.63
M C Naik	0	8	3	2	13	1970-1980	11	1.18
S Dhanya	13	0	0	0	13	1986-1997	12	1.08
S R Dharwadkar	0	12	1	0	13	1972-1988	17	0.76
A C Momin	0	12	1	0	13	1970-1987	18	0.72

C Karunakaran	0	8	4	1	13	1976-1997	22	0.59
T Laurent	12	0	0	0	12	1995-1997	3	4.00
G Ritter	0	3	9	0	12	1981-1985	5	2.40
B K Mishra	1	11	0	0	12	1989-1995	7	1.71
R A Gunasekaran	0	12	0	0	12	1990-1996	7	1.71
B S Valaulikar	0	12	0	0	12	1985-1996	12	1.00
E Konig	0	2	10	0	12	1981-1992	12	1.00
R Visalakshi	0	0	12	0	12	1982-1998	17	0.71
T N Das	12	0	0	0	12	1982-1998	17	0.71
M S Panajkar	6	1	1	4	12	1975-1997	23	0.52
J Wolfrum	11	0	0	0	11	1993-1997	5	2.20
R Ganguly	0	11	0	0	11	1995-1999	5	2.20
R J Butcher	0	1	10	0	11	1993-1998	6	1.83
Janaky Narayanan	0	11	0	0	11	1992-1998	7	1.57
R Sasikala	0	8	3	0	11	1985-1996	12	0.92
M Kumar	11	0	0	0	11	1987-1999	13	0.85
K D Asmus	11	0	0	0	11	1985-1998	14	0.79
K K Pushpa	5	4	1	1	11	1978-1997	20	0.55
S G Deshpande	0	0	11	0	11	1972-1991	20	0.55
L J Mittal	11	0	0	0	11	1973-1997	25	0.44
R K Iyer	0	2	9	0	11	1972-1997	26	0.42
A M Umarji	0	7	3	0	10	1987-1987	1	10.00
M Hillenkamp	10	0	0	0	10	1996-1998	3	3.33
P Somasundaram	1	9	0	0	10	1988-1990	3	3.33
V Vijaya Kumar	0	6	4	0	10	1980-1985	6	1.67
A J Swallow	10	0	0	0	10	1983-1990	8	1.25
B S M Rao	10	0	0	0	10	1991-1998	8	1.25
K Shashikala	0	9	1	0	10	1992-1999	8	1.25
V B Kartha	0	9	1	0	10	1991-1999	9	1.11
P K Mathur	0	0	6	4	10	1970-1980	11	0.91
J M Bruce	10	0	0	0	10	1983-1994	12	0.83
13 authors with 9 papers each	36	54	25	2	117			
16 authors with 8 papers each	49	24	50	5	128			
20 authors with 7 papers each	24	50	62	4	140			
21 authors with 6 papers each	35	60	28	3	126			
33 authors with 5 papers each	67	65	30	3	165			
41 authors with 4 papers each	64	60	36	4	164			
80 authors with 3 papers each	99	69	53	19	240			
134 authors with 2 papers each	101	92	59	16	268			
443 authors with 1 paper each	162	153	118	10	443			
Total authorships	2090	1985	1312	183	5570			

(A-Radiation & Photochemistry and Chemical Dynamics; **B**-Solid State Studies; **C**-Inorganic, Structural and Materials Chemistry; **D**-Theoretical Chemistry; FPY = First Publication Year; LPY = Last Publication Year; TY = Total Years; and APY = Authorships Per Year)

Verification of Lotka's Law

There were total 926 authors having the total of 5570 authorships (Table 3) for the Chemistry Division at BARC. The authorships in papers observed and expected as per Lotka's law (Lotka, 1926 ; Potter, 1981 ; Kalyane and Sen, 1995 ; Gupta, 1996) are shown in Figure 6. It follows the trend expected as per Lotka's law (α= 2).

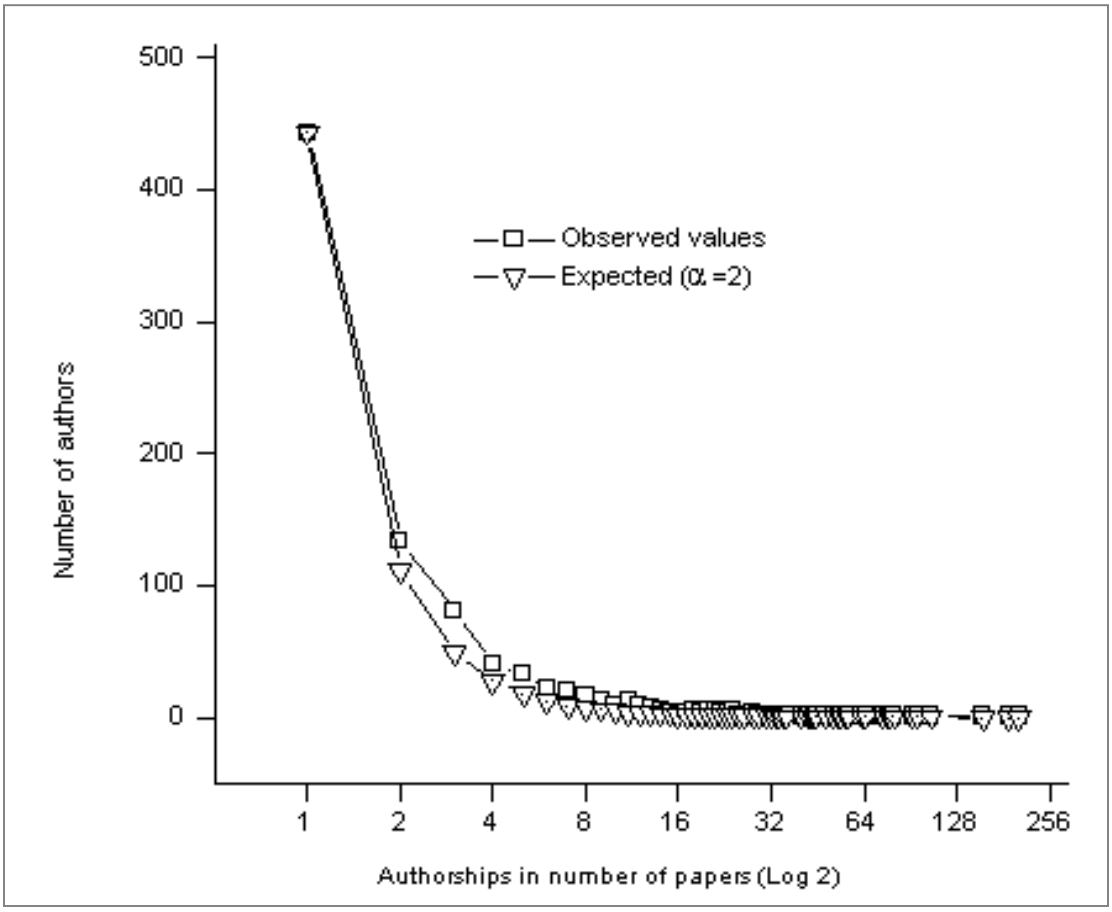

Figure 6: Author productivity of Chemistry Division at BARC during 1970-1999 as per Lotka's law

Preference of Channels of Communications by Scientists of Chemistry Division

The distribution of Chemistry Division's publications were spread over variety of publication media, Journals (1556, 89.78%), Technical Reports (113, 6.52%), Books (48, 2.77%), Patents (5, 0.29%) and Others (11, (0.64%). The leading journals preferred by the scientists are *Indian Journal of Chemistry-A* with 96 papers, *Radiation Physics and Chemistry* with 92 papers, *Chemical Physics Letters* with 67 papers, *Journal of Physical Chemistry* with 59 papers and *Indian Journal of Chemistry* with 45 papers. Figure-7 presents growth of papers published in top five preferred journals. Journalwise scattering of publications is provided in Table 4 and Figure 8.

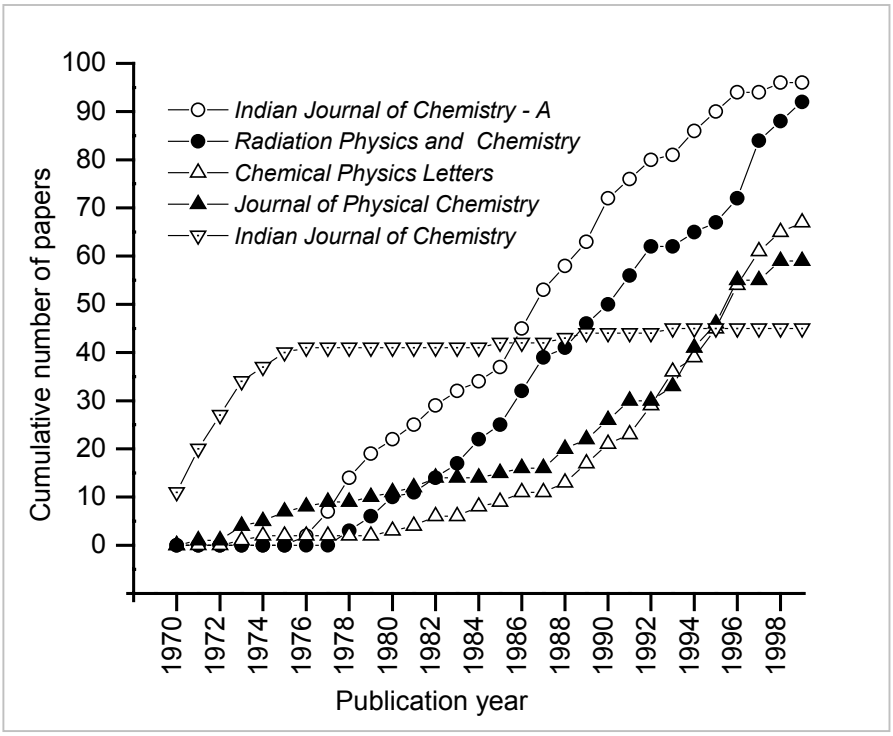

Figure 7: Growth of publications in five most preferred journals

Table 4: Journals preferred for publishing articles by the Scientists of Chemistry Division at BARC during 1970-1999

No.	Journal Title	Country	IF	Number of papers	Cummulative	FPY - LPY	TY
1.	*Indian J Chem A*	India	0.41	96	96	1976-1998	23
2.	*Radiat Phys Chem*	UK	0.82	92	188	1978-1999	22
3.	*Chem Phys Lett*	The Netherlands	2.36	67	255	1973-1999	27
4.	*J Phys Chem*	USA	-	59	314	1971-1998	28
5.	*Indian J Chem*	India	-	45	359	1970-1976	7
6.	*Radiat Effects*	UK	-	43	402	1970-1988	19
7.	*Physica C*	The Netherlands	0.81	39	441	1988-1999	12
8.	*J Chem Soc Faraday Trans*	UK	-	36	477	1982-1998	17
9.	*J Photochem Photobiol A*	Switzerland	1.04	30	507	1988-1998	11
10.	*J Organometal Chem*	The Netherlands	1.8	29	536	1985-1997	13
11.	*J Nucl Mater*	The Netherlands	1.37	25	561	1970-1995	26
12.	*Solid State Comm*	UK	1.38	25	586	1971-1999	29
13.	*ISRAPS Bull*	India	-	18	604	1989-1998	10
14.	*J Inorg Nucl Chem*	UK	-	18	622	1970-1981	12
15.	*J Phys Chem A*	USA	2.63	18	640	1997-1998	2
16.	*Langmuir*	USA	2.96	17	657	1989-1998	10
17.	*Proc Indian Acad Sci Chem Sci*	India	0.32	17	674	1980-1998	19
18.	*Indian J Technol*	India	-	16	690	1971-1992	22
19.	*J Catalysis*	USA	3.29	16	706	1979-1997	19
20.	*Polyhydron*	UK	1.2	16	722	1985-1999	15
21.	*J Indian Chem Soc*	India	0.41	15	737	1971-1994	24
22.	*J Chem Phys*	USA	3.15	14	751	1974-1998	25
23.	*J Phys F*	UK	-	14	765	1971-1988	18
24.	*Physica B*	The Netherlands	0.66	14	779	1989-1999	11
25.	*Bull Mater Sci*	India	0.47	13	792	1972-1997	26
26.	*Inorg Chem*	The Netherlands	2.95	13	805	1982-1998	17
27.	*Indian J Pure Appl Phys*	India	0.21	11	816	1973-1995	23
28.	*J Photo Chem*	Switzerland	-	11	827	1984-1987	4
29.	*Mater Res Bull*	UK	0.72	11	838	1974-1999	26
30.	*Phys Stat Sol A*	Germany	1.03	11	849	1970-1992	23
31.	*Radiochem Radioanal Lett*	The Netherlands	-	11	860	1971-1977	7
32.	*Thermochim Acta*	The Netherlands	1.01	11	871	1978-1996	19
33.	*Thin Solid Films*	Switzerland	1.27	11	882	1971-1994	24
34.	*Int J Chem Kinet*	USA	1.33	10	892	1982-1999	18
35.	*J Appl Polym Sci*	USA	0.99	10	902	1975-1987	13
36.	*J Chem Soc Dalton Trans*	UK	2.82	10	912	1975-1998	24
37.	*J Colloid Interface Sci*	USA	1.53	10	922	1978-1997	20
38.	*J Mater Sci Lett*	UK	0.49	10	932	1986-1999	14

39.	*Spectrochim Acta A*	UK	0.84	10	942	1979-1992	14
40-42.	3 journals with 9 papers each			27	969		
43-56.	14 journals with 8papers each			112	1081		
57-61.	5 journals with 7 papers each			35	1116		
62-73.	12 journals with 6 papers each			72	1188		
74-80.	7 journals with 5 papers each			35	1223		
81-90.	10 journals with 4 papers each			40	1263		
91-109.	19 journals with 3 papers each			57	1320		
110-171.	62 journals with 2 papers each			124	1444		
172-283.	112 journals with 1 paper each			112	1556		

(IF = Impact Factor as per *Journal Citation Reports* 2002; FPY = First Publication Year; LPY = Last Publication Year; and TY = Total Years)

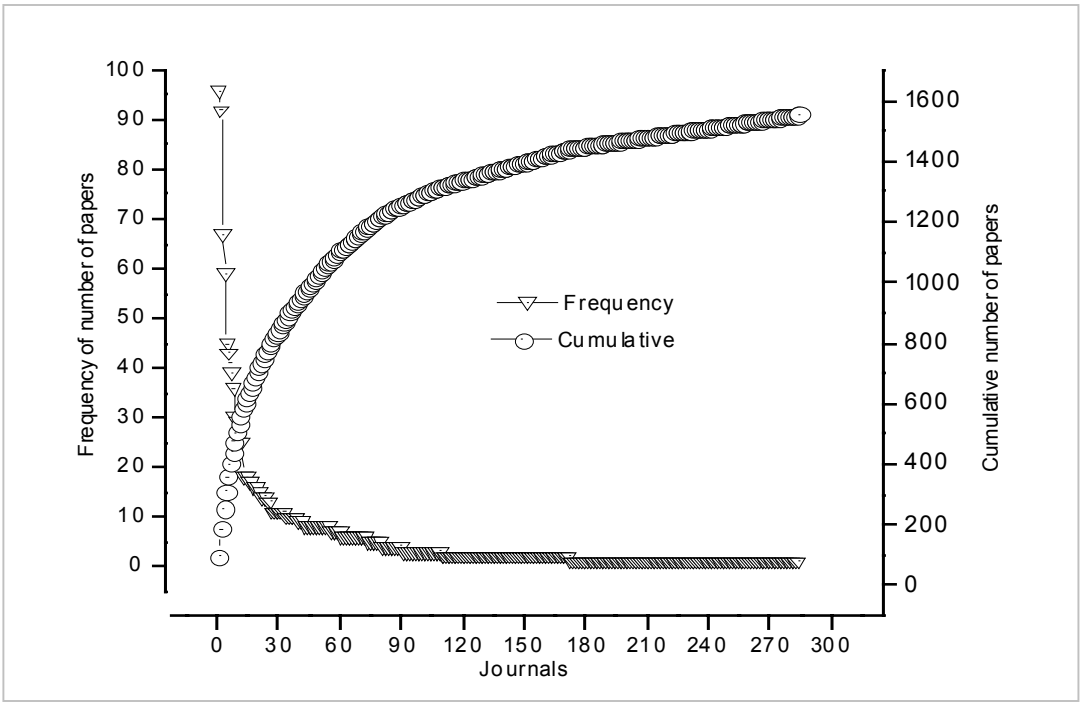

Figure 8: Bradford-Zipf bibliograph of distribution of journals used for publications

Publication density is defined by Vinkler (1990) as the ratio of the total number of papers published to the total number of journals in which the papers were published and publication concentration as the ratio in percentage of the journals containing half of the papers published to the total number of journals in which those papers were published during the period under study. The publication concentration observed in present study is 28.57%, publication density is 5.48 and Bradford multiplier is 3.35.

Countrywise Distribution of Journals

Figure 9 gives the countrywise distribution of journals publishing Chemistry Division's publications. Among the top ranking journals publishing the papers are from UK with 471 (30%) publications followed by India with 326 (21%) publications, The Netherlands with 302 (19%) publications, USA with 277 (18%) publications, Switzerland with 104 (7%) publications and Germany with 41 (3%) publications.

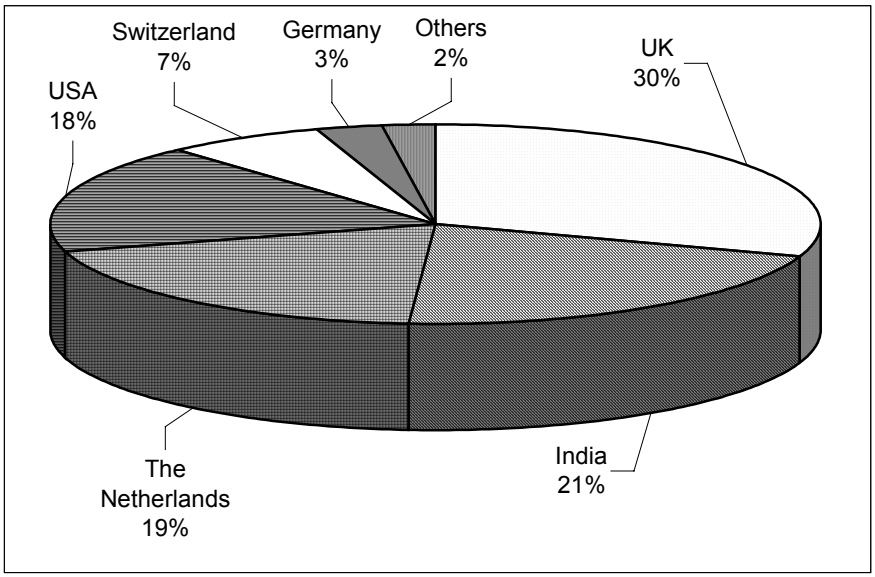

Figure 9: Country of publication of the journals which were preferred to publish papers from Chemistry Division at BARC during 1970-1999

Keyword Tomography

The recent study on Database Tomography (Kostoff, Eberhart, Toothman & Pellenbarg, 1997) for Research Impact Assessment is interesting. Titles of publications convey precisely the thought contents of the papers. The potency of information concentrated on the titles of the papers is more than the rest of the sections of the papers. Therefore, if a word occurs more frequently than expected to occur, then it reflects the emphasis given by the authors about the research field of their interest. The important words called 'keywords' are one of the best indicators to understand and grasp instantaneously the thought content of the papers, methodologies used and areas of research addressed to. The documentation of keywords appeared in the titles of all the publications was carried out and a list of keywords with at least five frequencies is given in Table 5.

CONCLUSION

This paper has highlighted quantitatively the contributions made by the scientists of Chemistry Division at BARC during 1970-1999. The Division has produced 1733 publications during this period with majority of publications produced during 1987-1998 in diverse areas of research such as Radiation & Photochemistry and Chemical Dynamics (649), Solid State Studies (558), Inorganic, Structural and Materials Chemistry (460) and Theoretical Chemistry (66). Highest number of publications (104) were produced in 1996. The collaboration trend among the Chemists towards multi-authored papers is indicative of the highly specialized areas of scientific work that they were engaged in. The most prolific authors identified in the study were/ are holding important positions in Bhabha Atomic Research Centre / Department of Atomic Energy which shows that publication productivity is one of the important indicators to identify the scientists for career advancements with additional responsibilities. The publication behaviour indicates that the chemists were highly selective in publishing their research results in highly specialized and high impact factor journals. It would be quite interesting to study other qualitative indicators based on citations and impact factors, participation in international meetings, academic qualifications and awards received by these scientists.

Table 5: Keywords with more than five frequencies appeared in the titles of publications of Chemistry Division at BARC during 1970-1999

Keyword	Frequency of occurrence	Keyword	Frequency of occurrence
Aqueous solutions	86	Hydrogen isotope effects	7
Formation	19	IR studies	7
Electrical resistivity	18	2,2'-bipyridine	6
Carbon monoxide (CO)	15	Chemiluminescent reactions	6
Hydrated electrons	14	CO_2 lasers	6
Dowex 50 w resins	12	Complexes	6
Crystal structures	11	Ion exchange resins	6
Interaction	11	Ion exchangers	6
Comparative study	10	Adsorption	5
Diffusion	10	Aerated solutions	5
Effect of pressure	10	Aggregation	5
Grafting	10	Applications	5
High temperature superconductors	10	Bilirubin	5
Coordination compounds	9	Catalyst activity	5
Dynamics	9	Cation distribution	5
Fullerenes (C_{60})	9	Decay kinetics	5
High pressure studies	9	Electrical conductivity	5
Hydrogen peroxide (H_2O_2)	9	Fluorescence quenching	5
Investigations	9	HFCVD technique	5
Absorption spectra	8	Hydrous oxides	5
High temperature behaviour	8	Hydroxyl radicals	5
Adsorption behaviour	7	Infrared multiphoton dissociation	5
Aqueous medium	7	Ion exchange equilibria	5
Determination	7	IRMPD	5
Electron transfer reactions	7	Pulse radiolysis studies	5
Gamma radiolysis	7		

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REFERENCES

Bishop, N., Gillet, V.J., Holliday, J.D. and Willet, P. 2003. Chemoinformatics research at the University of Sheffield: A history and citation analysis. *Journal of Information Science,* Vol. 29, no.4: 249-267.

Carpenter, M.P., Gibb, F., Harris, M., Irvin, J., Martin, B. R. and Narin, F. 1988. Bibliographic profiles for British academic institutions: An experiment to develop research output indicators. *Scientometrics*, Vol. 14, no.3-4: 213-233.

Cohen, J.E. 1981. Publication rate as a function of laboratory size in three biomedical research institutions. *Scientometrics*,Vol. 3, no.6: 467-487.

Dizon, L.B. and Sadorra, M.S.M. 1995. Patterns of publication by the staff of an International Fisheries Research Center. *Scientometrics*, Vol. 32, no.1: 67-75.

Frohlich, C. and Resler, L. 2001. Analysis of publications and citations from a Geophysics Research Institute. *Journal of the American Society for Information Science and Technology*, Vol. 52, no.9: 701-713.

Garg, K.C. and Rao, M.K.D. 1988. Bibliometric analysis of scientific productivity: A case study of an Indian physics laboratory. *Scientometrics*,Vol. 13, no.5-6: 261-269.

Gupta, B.M., Suresh Kumar and Khanna, H.K. 1999. Science in India: performance of Council of Scientific and Industrial Research laboratories based on the productivity profile of scientists. *Research Evaluation*, Vol. 8, no.3: 177-187.

Gupta, B.M. and Karisiddappa, C.R. 2000. Application of statistical models to the collaborative publications data in theoretical population genetics. *Malaysian Journal of Library & Information Science*, Vol. 5, no.1: 37-51.

Gupta, D.K. 1996. Lotka's law and it's application to author productivity distribution of psychological literature of Africa, 1966-1975 (2 pts.). In: Gupta, B.M. ed.

Handbook of Library Archives and Information Centres in India.Vol.13,New Delhi: Segment Books: 343-372.

Guay, Y. 1986. Emergence of basic research on the periphery: Organic chemistry in India, 1907-1926. *Scientometrics*, Vol. 10, no.1-2: 77-94.

Kalyane, V.L. and Kalyane, S.V. 1991. Scientometric dimensions of innovation communication productivity system. *Annals of Library Science and Documentation*, Vol. 38, no.1: 8-29.

Kalyane and Vidyasagar Rao K. 1992. Collaboration trends in sugercane research – A case study. *Annals of Library Science and Documentation*, Vol. 39, no.1: 9-11.

Kalyane, V.L. and Kalyane, S.V. 1994. Database on creativity and innovation communication productivity of science in India: A case study. *Journal of Information Sciences*, Vol. 7, no.1: 3-44.

Kalyane and Vidyasagar Rao K. 1995. Quantification of credits for authorship. *ILA Bulletin*, Vol. 30, no.3-4: 94-96.

Kalyane, V.L. and Sen, B.K. 1995. A bibliometric study of the Journal of Oilseeds Research. *Annals of Library Science and Documentation*, Vol. 42, no.4: 121-141.

Kalyane, V.L. and Kalyane, S.V. 1996. R & D communication strategy vis-à-vis librarianship. *Journal of Information Sciences*, Vol. 4, no.2: 105-135.

Kalyane, V.L. 1999. *BARC Progress Reports - 1998*. Mumbai: Library and Information Services Division, Bhabha Atomic Research Centre: 74-93.

Klaic, B. 1990. Scientometric analysis of the research activities of Chemists from the Rugjer Bošković Institute (Yugoslavia). 1976-1985. *Scientometrics*, Vol. 19, no.1-2: 11-24.

Kim, M.J. and Kim, B.J. 2000. A bibliometric analysis of publications by the Chemistry Department, Seoul National University, Korea, 1992-1998. *Journal of Information Science*, Vol. 26, no.2: 111-119.

King. J. 1998. The use of bibliometric techniques for institutional research evaluation : A study of Avian Virology Research. *Scientometrics*, Vol.41, no.3-4: 295-313.

Koganuramath, M.M., Angadi, M. and Kademani, B.S. 2002. Bibliometric dimension of innovation communication productivity of Tata Institute of Social Sciences. *Malaysian Journal of Library and Information Science*, Vol. 7, no.1: 69-76.

Kostoff, R.N., Eberhart, H.J., Toothman, D.R. and Pellenbarg, R. 1997. Database tomography for technical intelligence: Comparative roadmaps of the research impact assessment literature and the Journal of the American Chemical Society. *Scientometrics*, Vol. 40, no.1: 103-138.

Lee, C.K. 2003. A scientometric study of the research performance of the Institute of Molecular and Cell Biology in Singapore. *Scientometrics*, Vol. 56, no.1: 95-110.

Lotka, A.J. 1926. The frequency distribution of scientific productivity. *Journal of the Washington Academy of Sciences,* Vol. 16, no.12: 317-323.

Macrina, F.L. 2000. *Scientific Integrity: An Introductory Text with Case Studies*. Washington: ASM press.

Minor, L. and Dostatni, P. 1991. A bibliometric study of the publications of the French National Institute for Health and Medical Research (INSERM). *Scientometrics*, Vol. 22, no.1: 41-63.

Nalimov, V.V., Adler, Y.P. and Granovsky, Y.V. 1966. Information Systems in the Mathematical Theory of Experiment, In: V.V. Nalimov, ed. *Kibernetica i Dokumentalistik*. Mascow.

Narin, F. 1976. *Evaluative Bibliometrics: The Use of Publication and Citation Analysis in the Evaluation of Scientific Activities*. New Jersey: Computer Horizons, Inc.

Potter, W.G. 1981. Lotka's law revised. *Library Trends*, Vol. 3, no.1:21-39.

Price, D.J. De. S. 1965. *Little Science, Big Science*. Columbia: Columbia University Press: 86-91.

Pritchard, A. 1969. Statistical bibliography or bibliometrics. *Journal of Documentation*, Vol. 25, no.4: 348-349.

Salisbury, G.W. 1980. Research productivity of the State Agricultural Experiment Station System – measured by scientific publication output. *Illinois Agricultural Experiment Station Bulletin,* Vol. 762: 1-63.

Sapre, A.V. and Kesavdas, T. 1998. List of publications of Chemistry Division (1970-1997), In: *List of publications 1973-1997, Chemistry Group.* Mumbai: Bhabha Atomic Research Centre.

Schloegl, C., Gorraiz, J., Bart, C. and Bargmann, M. 2003. Evaluating two Australian university departments : Lessons learned. *Scientometrics,* Vol. 56, no.3 : 287 – 299.

Schubert, A. and Braun, T. 1981. Some scientometric measures of publishing performance for 85 Hungarian Research Institutes. *Scientometrics,* Vol. 3, no.5: 379-388.

Swarna, T., Kalyane, V.L. and Vijai Kumar. 2002. Scientometric dimensions of technical reports from Bhabha Atomic Research Centre. *Malaysian Journal of Library and Information Science*, Vol. 7, no.1: 17-30.

Ugolini, D., Parodi, S and Santi, L. 1997. Analysis of publication quality in Cancer Research Institute. *Scientometrics*, Vol. 38, no.2: 265-274.

Venkateswarlu, K.S. and George, A.M. 1998. *Chemistry in Atomic Energy Programmes : An Account of 50 Years, 1948- 1997 – A Saga of Excellence and Relevance*. Mumbai: Bhabha Atomic Research Centre.

Vinkler, P. 1990. Bibliometric analysis of publication activity of a scientific research Institute, In: L. Egge, and R. Rousseau, eds. *Informetrics.* Amsterdam : Elsevier Science Publishers: 309-334.

Yankevich, W.F.1982. Analysis of publication and invention productivity in some Soviet academic institutions. *Scientometrics*, Vol. 4, no.6: 431-437.

Zachos, G. 1991. Research output evaluation of two university departments in Greece with the use of bibliometric indicators. *Scientometrics*, Vol. 21, no.2: 195-221.