PUBLICATION PRODUCTIVITY OF THE BIO-ORGANIC DIVISION AT BHABHA ATOMIC RESEARCH CENTRE: A SCIENTOMETRIC STUDY

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Attempts to analyse quantitatively 475 papers published by the Bio-Organic Division of Bhabha Atomic Research Centre during 1972–2002 in various domains like Synthesis (202), Bioorganic Chemistry (100), Biotechnology (70), Natural Products (53), Waste Management (30), Supra-molecular Chemistry (18) and Organic Spectroscopy (2). The highest number of publications in a year were 38 in 2001. The average number of publications per year was 15.3 and the highest collaboration coefficient 1.0 was found in the years 1972,1976-1977,1980-1985,1987,1989-1990 and 1993. The most prolific authors were: A. Banerji (125), V. R. Mamdapur (93), S. Chattopadhyay (86), M. S. Chadha (61), S. K. Nayak (37), A. Chattopadhyay (30), L. P. Badheka (26), G. J. Chintalwar (26), S.K. Ghosh (25), and N. B. Mulchandani (25). The core journals preferred by the scientists to publish their papers include: Indian Journal of Chemistry-B (56), Tetrahedron Letters (20), Synthetic Communications (15), Journal of Organic Chemistry (14), Biotechnology Letters (12), Phytochemistry (12), Tetrahedron Asymmetry (11), Journal of Chemical Society- Perkin Transactions –I (10) and Molecules(10).

INTRODUCTION

Bio-Organic Division is one of the oldest divisions of Bhabha Atomic Research Centre established in the early stages of the Department of Atomic Energy to carry out research and developmental activities relevant to atomic energy programmes. The emphasis was laid on basic research with the aim to extend it to applied fields. During the period under study (1972-2002), the Division had been consistently concentrating its research activities in the areas of Bio-organic Chemistry, Biotechnology, Synthesis, Natural Products, Organic Spectroscopy, Waste Management, and Supra-molecular Chemistry.

Evaluating the productivity of institutional research and developmental 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 the science policy makers and science administrators to make available adequate facilities and direct 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, individual researcher, as well as to map the growth of the research field. Kademani and Vijai Kumar [1 & 2] have given a bird's eye view of the bibliometric and scientometric techniques used to study various quantitative and qualitative aspects of scientific endeavours. Chidambaram [3] noted that research publications are clearly one of the quantitative measures for the basic research activity in a country. It must be added, however, that what excites the common man, as well as the scientific community, are the peaks of scientific and technological achievements, not just the statistics on publications. There are also other kinds of research and technology development-mission oriented, industry-oriented, country-specific, etc., which cannot obviously be measured by counting only the number of publications.

Publication and citation counts are being extensively used for evaluation purpose of an institution [4 to 21]. Many scientometric studies have also been conducted to evaluate the research and research institutes in the field of chemistry. Guay [22] studied the quantitative survey of the emergence of organic chemistry research in India during 1907-1926 covered by *Chemical Abstracts.* Chemists who were conducting research in India

were separated into three distinct groups, on the basis of their cultural identity and educational background. Important disparities between these groups have been stated, both in terms of research fields and publication outlets. Klaic [23] carried out the analysis of 2018 papers published during 1976-1985 by the chemists from the Rugjer Bošković Institute (Yugoslavia). Both publications and citation counts were used for the analysis. Kim and Kim [24] examined research performance of Chemists at Chemistry Department, Seoul National University, Korea, 1992-1998. A total of 651 papers published by the 29 faculty members were considered and both publication and citation counts were used for the study. No correlation was found between the number of papers by a particular Chemist and the average number of citations per paper for that Chemist. Bishop et. al. [25] 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. Kannappanavar, Swamy and Vijay Kumar [26] have studied the authorship trend and collaborative research in chemistry in India during 1996-2000 and reported the trend towards multi-authorship papers. Kademani et al [27] have studied the publication productivity of the Chemistry Division at Bhabha Atomic Research Centre, India. The study covered 1733 papers published during 1970-1999 in various domains. The study dealt with year-wise publication productivity, collaboration trend, author productivity and Lotka's law, most productive authors, use of communication channels by the chemists and country-wise distribution of journals. Kademani et al. [28] also conducted a study on the publication productivity of the Analytical Chemistry Division at Bhabha Atomic Research Centre, India. The analysis covered 724 papers published by the scientists during 1972-2003 in diverse domains.

OBJECTIVES

The chief objectives of the present study are to quantitatively document the publication productivity behaviour of scientists of Bio-Organic Division at Bhabha Atomic Research Centre (BARC):

- to find out yearwise publication productivity,
- to document domainwise publications productivity,
- to document domainwise authorship and collaboration pattern,
- to identify the prolific authors having large number of publications,
- to identify the types of communication channels preferred,
- to find out the countrywise distribution of journals, and
- to document high frequency keywords from titles of the papers.

MATERIALS AND METHODS

A total of 475 publications, published by the scientists of Bio-Organic Division at Bhabha Atomic Research Centre during 1972-2002 as per the bibliography compiled by Subbaraman and Chattopadhyay [29] and the publications included in BARC Annual Progress Reports (1998 to 2002) [30] 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 spread sheet application. After validation, the data was analysed as per the objectives of the study.

RESULTS AND DISCUSSION

Yearwise growth of publications

During the years 1972 to 2002, Bio-Organic Division at BARC has produced a total of 475 publications. Figure 1 and Table 1 present the year wise publication productivity, authorship pattern (single author and multi author), collaboration trend among scientists and cumulative growth of publications. The highest number of publications was 38 in 2001 and the average number of publications per year was 15.32. About 93 % of publications were multi-authored and only 7 % of publications were single-authored. It is indicative of the trend towards multi-authored papers. The highest collaboration coefficient 1.0 was found in the years 1972, 1976-1977, 1980-1985, 1987, 1989-1990 and 1993 as there were no single authored papers during this period. To measure the collaborative research pattern a simple indicator called collaboration coefficient (number of collaborative papers divided by total number of papers) [31] was used. The division did not publish any papers in 1975.

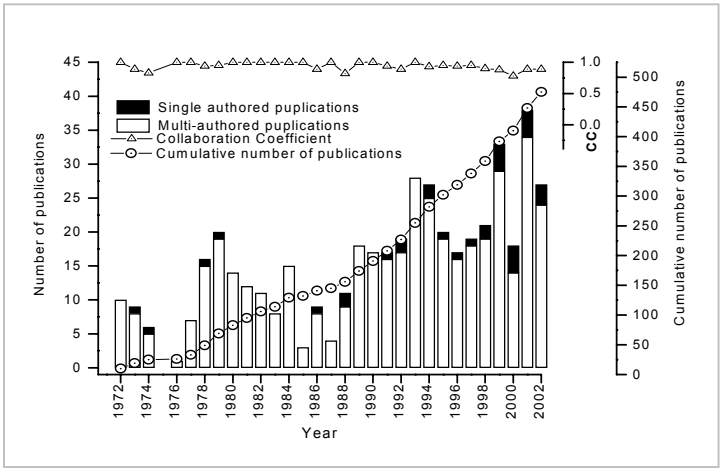

Figure 1 – Chronological publication productivity trend of Bio-Organic Division at BARC

Table 1 – Yearwise productivity and collaboration coefficient in the publications of Bio-Organic Division at BARC

Year	Single authored papers	Multi- authored papers	Total	Cumulative	Collaboration Coefficient
1972	0	10	10	10	1
1973	1	8	9	19	0.89
1974	1	5	6	25	0.83
1975	0	0	0	25	0
1976	0	1	1	26	1
1977	0	7	7	33	1
1978	1	15	16	49	0.94
1979	1	19	20	69	0.95
1980	0	14	14	83	1
1981	0	12	12	95	1
1982	0	11	11	106	1
1983	0	8	8	114	1
1984	0	15	15	129	1
1985	0	3	3	132	1

1986	1	8	9	141	0.89
1987	0	4	4	145	1
1988	2	9	11	156	0.82
1989	0	18	18	174	1
1990	0	17	17	191	1
1991	1	16	17	208	0.94
1992	2	17	19	227	0.89
1993	0	28	28	255	1
1994	2	25	27	282	0.93
1995	1	19	20	302	0.95
1996	1	16	17	319	0.94
1997	1	18	19	338	0.95
1998	2	19	21	359	0.9
1999	4	29	33	392	0.88
2000	4	14	18	410	0.78
2001	4	34	38	448	0.89
2002	3	24	27	475	0.89
Total	32	443	475		0.93

Domainwise contributions

During 1972 to 2002, Bio-Organic Division of BARC has contributed significantly to the following main subject areas.

A = Bio-organic Chemistry,
B = Biotechnology,
C = Synthesis,
D = Natural Products,
E = Organic Spectroscopy,
F = Waste Management, and
G = Supra-molecular Chemistry.

There were 202 publications in ‘Synthesis’ followed by ‘Bio-organic Chemistry’ with 100 publications, ‘Biotechnology’ with 70 publications, ‘Natural Products’ with 53 publications, ‘Waste Management’ with 30 publications, ‘Supra-molecular Chemistry’ with18 papers and ‘Organic Spectroscopy’ with two publications as it is a new domain. The domainwise annual growth of publications is presented in Figure 2. The highest number of publications 13 each in 1988 and 1989 were published in domain ‘Synthesis’ followed by 12 publications in 2001 in domain ‘Bio-organic Chemistry’.

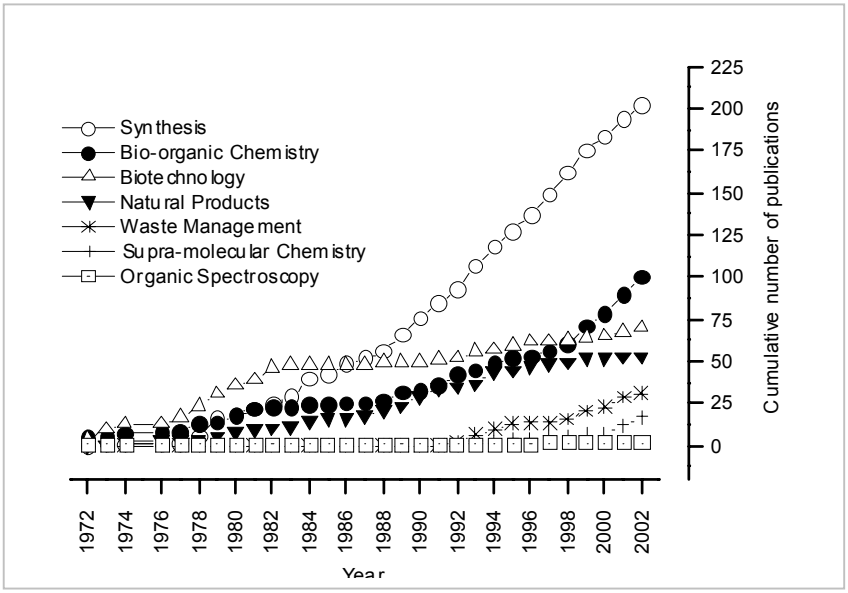

Figure 2 – Domain-wise growth of publications of Bio-organic Division at BARC

Domainwise authorship and collaboration pattern

Domainwise authorship pattern and number of publications in each domain are presented in Table 2. Authorship trend is towards multi-authored papers. Two authored papers account for 33.89% followed by three-authored papers 29.68% and four authored papers 16.63%. There is a similar trend in the domains 'Bio-Organic Chemistry', 'Biotechnology, and 'Synthesis' that more number of papers are two, three and four authored papers but 'Waste Management' domain had 23 papers with five to fourteen authored papers with no single authored papers. There are also some inter-divisional and international collaborative papers which indicates the multidisciplinary nature of the research activity being carried out in the division.

Table 2 – No. of papers having domainwise authorship pattern in the publications of Bio-Organic Division at BARC during 1972-2002

Authorships	Domains							Total Number of papers	%
	A	B	C	D	E	F	G		
ONE	11	10	9	2				32	6.74
TWO	17	39	87	16	1		1	161	33.89
THREE	25	14	79	18	1	1	3	141	29.68
FOUR	26	6	25	13		6	3	79	16.63
FIVE	9	1	2	2		5	11	30	6.32
SIX	6			1		4		11	2.32
SEVEN	2			1		2		5	1.05
EIGHT	2					5		7	1.47
NINE	2					4		6	1.26
TEN						2		2	0.42
FOURTEEN						1		1	0.21
Total	100	70	202	53	2	30	18	475	100

A-Bio-organic Chemistry; B-Biotechnology; C-Synthesis; D-Natural Products; E-Organic Spectroscopy; F-Waste Management; and G-Supra-molecular Chemistry

Twentieth century has seen tremendous collaborative research trend 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 breakthroughs [32].

De Solla Price [33] 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 [33] and Kademani et al [27 & 28, 35 to 37] 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 3. From this figure one can easily visualize the productivity of scientists in terms of their authorships and their association for the first paper with the Division .The Bio-Organic Division had 306 scientists producing 475 papers with 1488 authorships during the period under study.

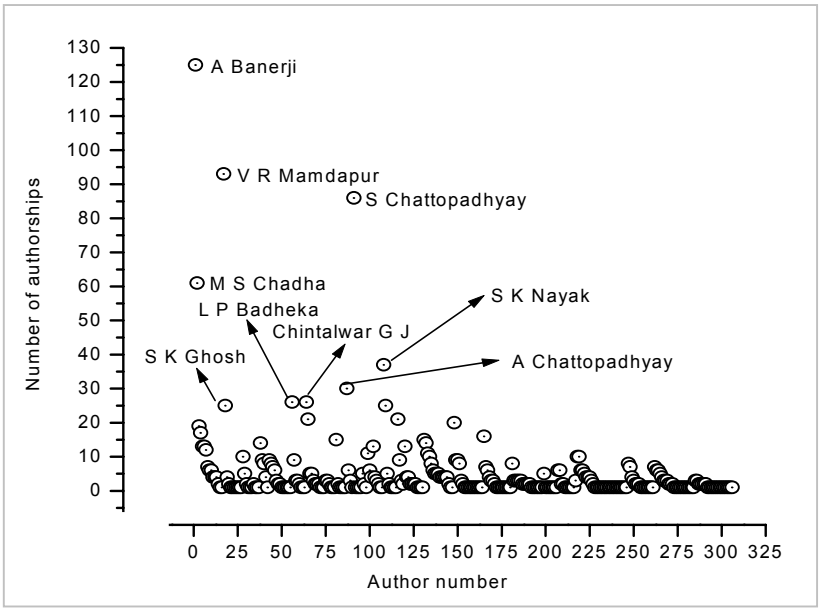

Figure 3 – Authorship profile of scientists of Bio-Organic Division at BARC depicting their association as per occurrence of name in the byline of first paper by each one (Author number) during 1972-2002

Most prolific authors

The most prolific authors were A. Banerji (1972-2002) who topped the list with 125 papers during the period under study followed by V. R. Mamdapur (1973-1999) with 93 publications, S. Chattopadhyay (1984-2002) with 86 publications, M. S. Chadha (1972-

1996) with 61 publications, S. K. Nayak (1989-2002) with 37 publications, A. Chattopadhyay (1983-2002) with 30 publications, L. P. Badheka (1979-2002),G. J. Chintalwar (1980-2002) with 26 publications each, and S. K. Ghosh (1989-2002), N. B. Mulchandani (1973-1992) with 25 publications each. Table 3 provides a list of 72 authors out of 306 who have contributed at least five papers each. One can also visualise from the table the status of the researchers whether they are active (publishing currently), inactive or retired (not publishing papers for a longer period) and the number of authorships produced per year.

Table 3 – Authorship credits during First Paper Year and Last Paper Year and Authorships Per Year in publications from Bio-Organic Division (1972-2002) at BARC

Sl. No.	Authors	Domainwise number of authorships							Number of authorships	Period of productivity FPY-LPY	TPY	APY
		A	B	C	D	E	F	G				
1	Banerji A	28	9	46	27	0	13	2	125	1972-2002	31	4.03
2	Mamdapur VR	2	2	85	4	0	0	0	93	1973-1999	27	3.44
3	Chattopadhyay S	17	13	42	1	0	3	10	86	1984-2002	19	4.53
4	Chadha MS	10	12	37	2	0	0	0	61	1972-1996	25	2.44
5	Nayak SK	1	0	23	1	0	2	10	37	1989-2002	14	2.64
6	Chattopadhyay A	0	1	29	0	0	0	0	30	1983-2002	20	1.5
7	Badheka LP	0	0	1	5	0	19	1	26	1979-2002	24	1.08
8	Chintalwar GJ	18	1	1	5	0	1	0	26	1980-2002	23	1.13
9	Ghosh SK	1	0	24	0	0	0	0	25	1989-2002	14	1.79
10	Mulchandani NB	3	2	4	16	0	0	0	25	1973-1992	20	1.25
11	Kalena GP	6	0	14	1	0	0	0	21	1980-2001	22	0.95
12	Pradhan P	0	0	4	14	0	0	3	21	1990-1999	10	2.1
13	Sharma A	0	6	13	0	0	0	1	20	1993-2002	10	2
14	Rao PS	1	18	0	0	0	0	0	19	1972-1983	12	1.58
15	Subbaraman AS	8	0	9	0	0	0	0	17	1972-1999	28	0.61
16	Talukdar S	0	0	14	0	0	0	2	16	1994-2002	9	1.78
17	Mathur JN*	0	0	0	0	0	15	0	15	1992-2001	10	1.5
18	Venkatachalam SR	12	0	2	1	0	0	0	15	1982-2000	19	0.79
19	Hassarajani SA	1	0	9	4	0	0	0	14	1977-2002	26	0.54
20	Murali MS*	0	0	0	0	0	14	0	14	1992-1999	8	1.75
21	Choughuley ASU	12	0	0	1	0	0	0	13	1972-1993	22	0.59
22	Luthria DL	5	0	1	7	0	0	0	13	1988-1994	7	1.86
23	Salvi NA	3	5	1	0	0	4	0	13	1991-2002	12	1.08
24	Sipahimalani AT	1	1	0	10	0	1	0	13	1972-1999	28	0.46
25	Udupa SR	0	8	1	1	0	2	0	12	1972-1998	27	0.44
26	Dhami PS*	0	0	0	0	0	11	0	11	1992-2002	11	1
27	Mithran S	0	0	11	0	0	0	0	11	1986-1999	14	0.79
28	Gopalakrishnan V*	0	0	0	0	0	10	0	10	1992-2001	10	1
29	Heble MR	0	9	0	1	0	0	0	10	1974-1983	10	1
30	Manchanda VK*	0	0	0	0	0	9	1	10	1999-2002	4	2.5
31	Rele S	4	0	6	0	0	0	0	10	1999-2002	4	2.5
32	Bapat VA	0	9	0	0	0	0	0	9	1977-1982	6	1.5
33	Eapen S	1	8	0	0	0	0	0	9	1978-2002	25	0.36
34	Goomer NC	0	0	9	0	0	0	0	9	1979-1988	10	0.9
35	Kokate SD	9	0	0	0	0	0	0	9	1990-2002	13	0.69

Sl. No.	Authors	Domainwise number of authorships							Number of authorships	Period of productivity FPY-LPY	TPY	APY
		A	B	C	D	E	F	G				
36	Pawar AS	0	1	8	0	0	0	0	9	1993-1997	5	1.8
37	Ramanujam A*	0	0	0	0	0	9	0	9	1993-2002	10	0.9
38	Adhikari S*	8	0	0	0	0	0	0	8	2000-2002	3	2.67
39	Bhide GV	0	0	8	0	0	0	0	8	1977-1993	17	0.47
40	Iyer RH	0	0	0	0	0	8	0	8	1993-1996	4	2
41	Kulkarni BA	0	0	8	0	0	0	0	8	1992-1997	6	1.33
42	Sankaranarayanan S	0	1	7	0	0	0	0	8	1995-2002	8	1
43	Subramaniam CS	0	0	8	0	0	0	0	8	1978-1979	2	4
44	Banerjee M	1	0	0	0	0	0	6	7	2001-2002	2	3.5
45	Fleming I*	0	0	7	0	0	0	0	7	1994-1998	5	1.4
46	Mukherjee T*	6	0	0	0	0	0	1	7	2000-2002	3	2.33
47	Narayanaswamy S*	1	6	0	0	0	0	0	7	1972-1982	11	0.64
48	Ramakrishnan V	6	0	0	1	0	0	0	7	1978-1993	16	0.44
49	Bhattacharya RK*	5	0	0	1	0	0	0	6	1992-1998	7	0.86
50	Bhattacharya S*	0	0	0	0	0	0	6	6	2001-2002	2	3
51	Dhotare B	0	0	6	0	0	0	0	6	1997-2001	5	1.2
52	George L	1	5	0	0	0	0	0	6	1972-1982	11	0.55
53	Joshi NN	0	0	6	0	0	0	0	6	1983-1984	2	3
54	Kazi ZA	6	0	0	0	0	0	0	6	1972-1980	9	0.67
55	Mahajan GR*	0	0	0	0	0	6	0	6	1999-2002	4	1.5
56	Mukherjee AK*	0	0	0	0	0	0	6	6	2001-2002	2	3
57	Nair CKK	6	0	0	0	0	0	0	6	1994-2000	7	0.86
58	Prabhu BR	0	0	0	6	0	0	0	6	1986-1994	9	0.67
59	Prabhu DR*	0	0	0	0	0	6	0	6	1999-2002	4	1.5
60	Rao KN*	6	0	0	0	0	0	0	6	1997-2000	4	1.5
61	Thomas PJ	0	0	6	0	0	0	0	6	1978-1979	2	3
62	Chaturvedi R	0	0	2	3	0	0	0	5	1989-1992	4	1.25
63	Devasagayam TPA*	5	0	0	0	0	0	0	5	1980-2002	23	0.22
64	Dhumwad RK	0	0	0	0	0	5	0	5	1992-1994	3	1.67
65	Iyer RR	0	0	5	0	0	0	0	5	1985-1989	5	1
66	Kadam SM	1	0	4	0	0	0	0	5	1992-1995	4	1.25
67	Kapoor SC*	1	0	0	0	0	4	0	5	1992-2000	9	0.56
68	Patro BS	4	0	0	1	0	0	0	5	1999-2002	4	1.25
69	Rangan TS	0	5	0	0	0	0	0	5	1974-1981	8	0.63
70	Sen G	3	0	0	2	0	0	0	5	1980-1981	2	2.5
71	Subramaniam M	4	0	0	1	0	0	0	5	2001-2002	2	2.5
72	Verma R	0	0	5	0	0	0	0	5	1996-1999	4	1.25
73-92.	20 authors with 4 papers each	11	12	22	13	2	20	0	80			
93-117.	25 authors with 3 papers each	32	5	11	3	0	15	9	75			
118-159.	42 authors with 2 papers each	44	6	13	9	2	4	6	84			
160-306.	147 authors with 1 paper each	59	14	18	22	1	21	12	147			
1-306.	Total authorships	353	159	530	163	5	202	76	1488			

(A-Bioorganic Chemistry; B-Biotechnology; C-Synthesis; D-Natural Products; E-Organic Spectroscopy; F-Waste Management; G-Supra-molecular Chemistry; *-Collaborators not Belonging to Bio-Organic Division ; FPY = First Publication Year; LPY = Last Publication Year; TPY = Total Productive Years; APY = Authorships Per Year)

Preference of channels of communications by scientists of Bio-Organic Division

Distribution of publications in types of documents is depicted in Figure 4. The Bio-Organic Division's publications were spread over variety of publication media, Journals (401) (84.4 %), Conference Papers (42) (8.8 %), Books (16) (3.3 %), Reports (13) (2.7%) and Patents (3) (0.63%). The leading journals preferred by the scientists are *Indian Journal of Chemistry-B* with 56 papers, *Tetrahedron Letters* with 20 papers, *Synthetic Communications* with 15 papers, *Journal of Organic Chemistry with 14 papers, Biotechnology Letters* and *Phytochemistry* with 12 papers each*, Tetrahedron Asymmetry* with 11 papers and *Journal of Chemical Society- Perkin Transactions –I* and *Molecules* with 10 papers each. Journalwise scattering of publications is provided in Table 4. The publications were published in 126 different journals.

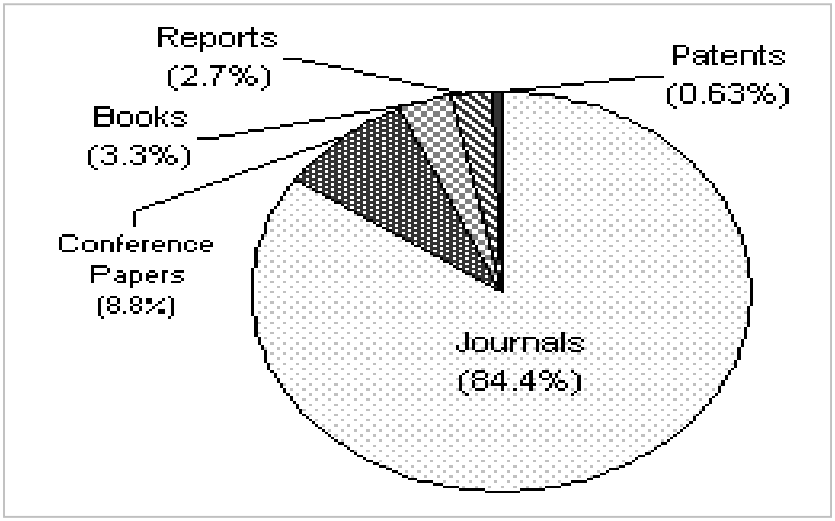

Figure 4 – Preference of channels of communications by scientists of Bio-Organic Division at BARC during 1972-2002

Table 4 – Journals preferred for publishing articles by the scientists of Bio-Organic Division at BARC during 1972-2002

Sl. No.	Journal Title	Country	IF	Number of papers	Cumulative	Publication period (FPY - LPY)	TY
1	*Indian J Chem-B*	India	0.492	56	56	1978-2001	24
2	*Tetrahedron Lett*	England	2.326	20	76	1973-2002	30
3	*Synth Commun*	USA	0.853	15	91	1980-1998	19
4	*J Org Chem*	USA	3.297	14	105	1991-2002	12
5	*Biotechnol Lett*	Netharland	0.778	12	117	1993-2002	10
6	*Phytochem*	England	1.889	12	129	1974-1999	26
7	*Tetrahedron Asymm*	England	2.178	11	140	1995-2002	8
8	*J Chem Soc Perkin-Trans I*	England	1.948	10	150	1976-2002	27
9	*Molecules*	Switzerland	0.911	10	160	1997-2001	5
10	*Planta Med*	Germany	1.879	9	169	1973-1994	22
11	*Indian J Biochem Biophys*	India	0.252	8	177	1972-1989	18
12	*Tetrahedron*	England	2.641	8	185	1984-2001	18
13	*J Chem Soc Chem Commun*	UK	-	7	192	1972-1997	26
14	*Indian J Exp Biol*	india	-	6	198	1972-1992	21
15	*J Natur Prod*	USA	1.849	6	204	1979-1994	16
16	*Plant Sci Lett*	Ireland	-	6	210	1977-1980	4
17	*Z Pflanzenphysiol*	Germany	-	6	216	1973-1982	10
18	*Chem Indus-London*	England	0.192	5	221	1979-1986	8
19	*J Agri Food Chem*	USA	2.102	5	226	1985-1993	9
20	*Spect Lett*	USA	0.576	5	231	1990-1997	8
21	*Synthesis*	Germany	2.074	5	236	1980-2002	23
22	*J Chem Res*	England	0.382	4	240	1989-2002	14
23	*J Indian Chem Soc*	India	0.275	4	244	1981-1997	17
24	*J Radioanal Nucl Chem Lett*	Switzerland	-	4	248	1992-1995	4
25	*Org Prep Proc Intnl*	USA-	-	4	252	1993-1994	2
26	*Steroid*	USA	2.444	4	256	1979-1979	1
27	*Ann Bot*	England	1.37	3	259	1973-1980	8
28	*Cancer Lett*	Netharland	2.614	3	262	1992-1998	7
29	*Chemosphere*	England	1.904	3	265	1988-1994	7
30	*Current Science*	India	0.694	3	268	1978-1994	17
31	*J Appl Entomol*	Germany	0.381	3	271	2001-2001	1
32	*Annalen der Chem*	Germany	-	3	274	1993-1996	4
33	*Plant Cell Reports*	Germany	1.423	3	277	1981-1982	2
34	*Spectrochimica Acta Part-A*	England	1.315	3	280	2001-2002	2
35	*J Labell Comps & Radiopharm*	UK	-	3	283	1981-1988	7
27 journals with 2 papers each		-	-	54	337	1972-2002	31
64 .journals with 1 paper each		-	-	64	401	1972-2002	31

(IF = Impact Factor as per *Journal Citation Reports* 2003; FPY = First Publication Year; LPY = Last Publication Year; and TY = Total Years)

Publishing Countrywise distribution of journals

The publications have been spread in 126 journals published from 13 countries. Figure 5 gives the countrywise distribution of journals publishing Bio-Organic Division's publications. Among the top ranking journals publishing the papers are from UK with 108 (26.93%) publications, followed by India with 95 (23.69%) publications, USA with 84 (20.95 %) publications, Germany, The Netherlands with 35 (8.73 %) publications each and Switzerland with 17 (4.24%) publications.

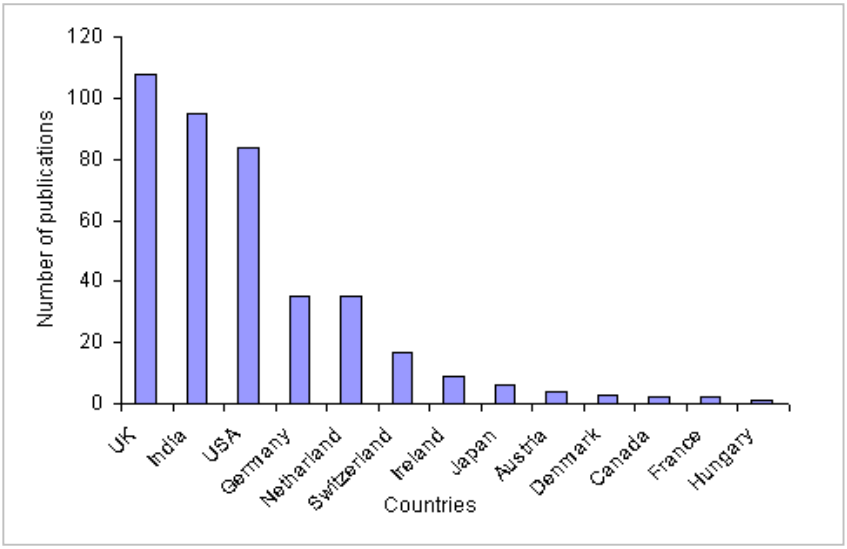

Figure 5 – Countrywise distribution of journals preferred for publication by the Scientists of Bio-Organic Division at BARC

Documentation of keywords

Titles of publications convey 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. Documentation of keywords appeared in the titles of all the publications was carried out and a list of keywords with at least three frequencies is given in Table 5.

Table 5 – Keywords with more than three frequencies appeared in the titles of publications of Bio-Organic Division at BARC during 1972-2002

Keyword	Freq.	Keyword	Freq.	Keyword	Freq.
Synthesis	83	Aldehydes	4	DNA Binding Studies	3
Low Valent Titanium	26	Anti-Juvenile Hormones	4	Dysdercus Cingulatus	3
Convenient Synthesis	18	Antimicrobial Principles	4	EDA Complexes	3
Tissue Cultures	16	Antioxidant Properties	4	Embryos	3
Pheromones	15	Asymmetric Synthesis	4	Flavonoids	3
Facile Synthesis	13	Bakuchiol	4	Heterocyclic Steroids	3

CMPO	11	Biochemical Process	4	High Resolution NMR Spectroscopy	3
Biosynthesis	10	Calixarenes	4	Homochiral Functionalized Alcohols	3
Rhizopus Arrhizus	9	Cell Growth	4	Indian Piper Species	3
Tinospora Cordifolia	9	Chemoenzymatic Synthesis	4	Insect Control	3
Total Synthesis	9	Cocoon	4	Insecticidal Principle	3
Natural Products	8	Expedient Synthesis	4	Isolation	3
Plumbagin	8	High Level Waste Streams	4	Microbiological Transformations	3
Applications	7	In Vitro Cultures	4	Morphogenetic Investigations	3
Callus Cultures	7	Marine Sponge	4	New Synthesis	3
Insects	7	Naturally Occurring Compounds	4	NMR Spectroscopy	3
Organic Synthesis	7	Nonactin	4	n-Triacontynols	3
Tylophorinidine	7	Stereocontrolled Synthesis	4	One-Step Synthesis	3
Characterisation	6	Synthetic Applications	4	Partioning	3
Enantiomeric Synthesis	6	Thymidylate Synthase Activity	4	Partitioning of Actinides	3
Inhibition	6	Flavanones	4	Pergularinine	3
Preparation	6	[60]-Fullerenes	4	Petunia Inflata R. Fries	3
Sex Pheromones	6	13C-NMR Spectroscopy	3	Phenanthroindolizidine Alkaloids	3
Silicon	6	Americium	3	Physalis Minima Linn	3
Silkworm, Bombyx Mori L	6	Anther Culture	3	Pimpinella Monoica	3
Simple Synthesis	6	Aqueous Solutions	3	Pineapple	3
(R)-2,3-O-Cyclohexylidene Glyceraldehyde	5	Aristolactams	3	Plant Alkaloids	3
Actinides	5	Biosorption	3	Prostanoid Synthons	3
Alkaloids	5	Biotechnological Applications	3	Pulse Radiolysis Study	3
Antioxidant Activities	5	Brief Synthesis	3	Queen Bee Pheromones	3
Extraction	5	Chemistry	3	Recovery of Plutonium	3
Mutagenicity	5	Chiral Synthesis	3	Roots	3
Nitrosating Agents	5	Chromatographic Separation	3	Short Synthesis	3
Stereochemistry	5	Crematogaster Ants	3	Transport	3
Stereoselective Synthesis	5	Cribochalina Vasculum	3	Tylophora Indica Merr	3
TBP	5	Deoxytubulosine	3	Versatile Intermediate	3
[70]-Fullerenes	4	Derivatives	3		
2D NMR Spectroscopy	4	Dihydrofolate Reductase	3		

CONCLUSION

The paper has highlighted quantitatively the contributions made by the scientists of Bio-Organic Division at BARC during 1972-2002.The Division has produced 475 publications in various domains. The highest number of publications (38) were produced in 2001. The collaboration trend among the scientists 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 scientists were highly selective in publishing their research results in highly specialized journals.It would be useful to study other qualitative indicators based on citations and impact factors, participation in international meetings, academic qualifications, honours and awards received by these scientists. This kind of studies are useful to enable the policy makers and science administrators to take appropriate decisions.

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REFERENCES

1. KADEMANI (B S) and VIJAI KUMAR. Bibliometrics: An innovative tool to measure the growth of knowledge and impact studies for policy makers, *UGC Sponsored refresher Course on "Information Technology for Librarians", 06-26 September 2004,* TISS, Mumbai. 2004; 1-21.
2. KADEMANI (B S) and VIJAI KUMAR. Citation Index: An indespensable information retrieval tool for research and evaluation, *ICSSR Sponsored Training Workshop on Exploring Social Science Information in Digital Environment*, 27 –30 May 2002 , TISS,Mumbai.2002; 62- 75.
3. CHIDAMBARAM (R). Measures of progress in science and technology. *Current Science*. 88,6; 2005; 856-860.
4. SALISBURY (G W). Research productivity of the State Agricultural Experiment Station System – measured by scientific publication output. *Illinois Agricultural Experiment Station Bulletin..* 762; 1980; 1-63.
5. COHEN (J E). Publication rate as a function of laboratory size in three biomedical research institutions. *Scientometrics*, 3, 6; 1981; 467-487.
6. SCHUBERT (A) and BRAUN (T). Some scientometric measures of publishing performance for 85 Hungarian Research Institutes. *Scientometrics.* 3, 5; 1981; 379-388.
7. YANKEVICH (W F). Analysis of publication and invention productivity in some Soviet academic institutions. *Scientometrics*. 4, 6; 1982; 431-437.
8. CARPENTER (M P), GIBB (F), HARRIS (M), IRVIN (J), MARTIN (B R) and NARIN (F). Bibliographic profiles for British academic institutions: An experiment to develop research output indicators. *Scientometrics.* 14, 3-4; 1988; 213-233.
9. GARG (K C) and RAO (M K D). Bibliometric analysis of scientific productivity: A case study of an Indian physics laboratory. *Scientometrics*. 13, 5-6; 1988; 261-269.
10. VINKLER (P). Bibliometric analysis of publication activity of a scientific research Institute, In: L. Egge, and R. Rousseau, eds. *Informetrics.* Amsterdam: Elsevier Science Publishers. 1990; 309-334.
11. ZACHOS (G). Research output evaluation of two university departments in Greece with the use of bibliometric indicators. *Scientometrics*. 21, 2; 1991; 195-221.
12. KALYANE (V L) and KALYANE (S V). Scientometric dimensions of innovation communication productivity system. *Annals of Library Science and Documentation*. 38, 1; 1991; 8-29
13. MINOR (L) and DOSTATNI (P). A bibliometric study of the publications of the French National Institute for Health and Medical Research (INSERM). *Scientometrics.* 22, 1; 1991; 41-63.
14. DIZON (L B) and SADORRA (M S M). Patterns of publication by the staff of an International Fisheries Research Center. *Scientometrics*. 32, 1; 1995; 67-75.
15. UGOLINI (D), PARODI (S) and SANTI (L). Analysis of publication quality in Cancer Research Institute. *Scientometrics*. 38, 2; 1997; 265-274.

16. KING (J). The use of bibliometric techniques for institutional research evaluation: A study of Avian Virology Research. *Scientometrics*. 41, 3-4; 1998; 295-313.
17. GUPTA (B M), SURESH KUMAR and KHANNA (H K). Science in India: performance of Council of Scientific and Industrial Research laboratories based on the productivity profile of scientists. *Research Evaluation*. 8, 3; 1999; 177-187.
18. FROHLICH (C) and RESLER (L). Analysis of publications and citations from a Geophysics Research Institute. *Journal of the American Society for Information Science and Technology.* 52, 9; 2001; 701-713.
19. KOGANURAMATH (M M), ANGADI (M) and KADEMANI (B S). Bibliometric dimension of innovation communication productivity of Tata Institute of Social Sciences. *Malaysian Journal of Library and Information Science.* 7, 1; 2002; 69-76.
20. LEE (C K). A scientometric study of the research performance of the Institute of Molecular and Cell Biology in Singapore. *Scientometrics.* 56, 1; 2003; 95-110.
21. SCHLOEGL (C), GORRAIZ (J), BART (C) and BARGMANN (M). Evaluating two Australian university departments: Lessons learned. *Scientometrics.* 56, 3; 2003; 287 – 299.
22. GUAY (Y). Emergence of basic research on the periphery: Organic chemistry in India, 1907-1926. *Scientometrics*. 10, 1-2; 1986; 77-94.
23. KLAIC (B). Scientometric analysis of the research activities of Chemists from the Rugjer Boškoviæ Institute (Yugoslavia). 1976-1985. *Scientometrics*. 19, 1-2; 1990; 11-24.
24. KIM (M J) and KIM (B J). A bibliometric analysis of publications by the Chemistry Department, Seoul National University, Korea, 1992-1998. *Journal of Information Science*. 26, 2; 2000; 111-119.
25. BISHOP (N), GILLET (V.J), HOLLIDAY (J D) and WILLET (P). Chemoinformatics research at the University of Sheffield: A history and citation analysis. *Journal of Information Science,* 29, 4; 2003; 249-267.
26. KANNAPPANAVAR (B U), SWAMY (C), and VIJAY KUMAR (M). Publishing trends of Indian chemical scientists: A bibliometric study. *Annals of Library and Information Studies*.51; 2004; 39-41.
27. KADEMANI (B S), VIJAI KUMAR, SURWASE (G), ANIL SAGAR, LALIT MOHAN, GADERAO (C R), ANIL KUMAR, KALYANE (V L) and PRAKASAN (E R). Scientometric dimensions of innovation communication productivity of the chemistry division at Bhabha Atomic Research Centre. *Malaysian Journal of Library & Information Science*. 10, 1; 2005; 65-89.
28. KADEMANI (B S), VIJAI KUMAR, LALIT MOHAN, ANIL SAGAR, ANIL KUMAR, GADERAO (C R) and SURWASE (G). Scientometric Dimensions and Publication Productivity of the Analytical Chemistry Division at Bhabha Atomic Research Centre. *SRELS Journal of Information management.* 43, 1 ; 2006 (in press).
29. SUBBARAMAN (A S) and CHATTOPADHYAY (S). List of publications of Bio-Organic Division (1972-1997), In: *List of publications 1973-1997, Chemistry Group*. Mumbai: Bhabha Atomic Research Centre. 1998.
30. BHABHA ATOMIC RESEARCH CENTRE. BARC Progress Reports (1998-2003), Mumbai: Library and Information Services Division, Bhabha Atomic Research Centre, 1999-2002.
31. SUBRAMANYAM (K). Biblimetric studies of research collaboration: A review. *Journal of Information Science.* 6,1; 1983; 33-38.
32. MACRINA (F L). *Scientific Integrity: An Introductory Text with Case Studies*. Washington: ASM press. 2000.
33. De SOLLA PRICE (D J). *Little Science, Big Science*. Columbia: Columbia University Press. 1965; 86-91.
34. GUPTA (B M) and KARISIDDAPPA (C R) Application of statistical models to the collaborative publications data in theoretical population genetics. *Malaysian Journal of Library & Information Science.* 5, 1; 2000; 37-51.
35. KADEMANI (B S), VIJAI KUMAR, ANIL SAGAR and ANIL KUMAR. Scientometric dimensions of nuclear science and technology research in India: A study based on INIS (1970-2002) database. *Malaysian Journal of Library and Information Science*. 11, 1; 2006 (in press).
36. KADEMANI (B S), VIJAI KUMAR, ANIL SAGAR, and ANIL KUMAR. World literature on thorium research: A scientometric study based on Science Citation Index . *Scientometrics* ; 2006 (in press).
37. KADEMANI (B S), VIJAI KUMAR, ANIL SAGAR, ANIL KUMAR, LALIT MOHAN, and SURWASE (G). Scientometric dimensions of thorium research in India (in press).