Malaysian Journal of Library & Information Science, Vol.11, no.1, July 2006: 23-48

SCIENTOMETRIC DIMENSIONS OF NUCLEAR SCIENCE AND TECHNOLOGY RESEARCH IN INDIA: A STUDY BASED ON INIS (1970-2002) DATABASE

B. S. Kademani, Vijai Kumar, Anil Sagar and Anil Kumar
Scientific Information Resource Division, Bhabha Atomic Research Centre,
Trombay, Mumbai – 400 085, India
e-mail: bskademani@yahoo.co.in; bsk@magnum.barc.ernet.in

ABSTRACT

This paper analyses quantitatively the growth and development of Nuclear Science and Technology research in India in terms of publication output as reflected in International Nuclear Information System (INIS) (1970-2002) database. During 1970-2002 a total of 55313 papers were published by the Indian Nuclear scientists in various domains: Physics (23033), Chemistry (16368), Life and Environmental Sciences (7203), Engineering and Technology (6960), Other Aspects of Nuclear and Non Nuclear Energy (981) and Isotopes and Radiation Application (768). Year-wise growth of publications and input of records to INIS database by India and other countries were analysed. The total number of records input to INIS database by India was 30356 (54.88%) and by other countries and international organizations 24957 (45.12%). The average number of papers published per year was 1676.15. The average Indian contribution to the world literature was 2.25%. Authorship and collaboration trend was towards multi-authored papers. Intensive international collaboration was found during the period and bilateral collaboration accounted for 80.06% of the total collaborative papers. More than 99% of publications were published in English. More than 60% of publications were published in journals. Most preferred journals by the scientists were Pramana 1327 (3.95%), Indian Journal of Pure and Applied Physics 1104 (3.29%), Physical Review-D 925 (2.75%), Journal of the Indian Chemical Society 783 (2.33%) and Indian Journal of Chemistry-A 734 (2.19%). High frequency Indexer Assigned Descriptors were: Gamma-radiation (4076), Temperature–dependence (3220), Experimental – data (2749), Radiation – doses (2306) and India (2000).

KEYWORDS: Nuclear science and technology; International Nuclear Information System; Scientometric analysis; International collaboration; Publication productivity; Authorship pattern; Communication channels; India

INTRODUCTION

Research in Nuclear Science and Technology in India was conceived in the pre-independence era by Homi Jehangir Bhabha, who grasped the significance of nuclear research and wrote to J.R.D Tata on 19 August 1943 for setting up an institute for fundamental research with financial assistance. The Tata Trust accepted the proposal of Homi Jehangir Bhabha on 14 April 1944. As a result the Tata Institute of Fundamental Research (TIFR) started functioning on June 1, 1945 from the premises of Indian Institute of Science, Bangalore. TIFR, formally inaugurated on December 19, 1945 at Kenilworth, Mumbai, was the cradle of Nuclear Science and Technology Research in India under the leadership of Homi Jehangir Bhabha. After the independence in August 1947, the Congress government led by Prime Minister Jawaharlal Nehru launched an ambitious nuclear programme to exploit the abundant natural thorium reserves. Formation of Atomic Energy Commission and passing of Atomic Energy Act on 15 April 1948 heralded a new era in the history of Indian nuclear science research. Bhabha was the architect of nuclear programme in India. He realised the importance of energy requirements of the country and said, "No power is as costly as no power".

The Department of Atomic Energy (DAE), which came into being on August 3, 1954, has been engaged in the development of nuclear power technology, application of radiation technologies in the fields of agriculture, medicine, industry and research. Nuclear science and technology research in India has progressed broadly in three phases. The first phase, extending roughly up to the mid-fifties, concentrated on the training of scientists who could, with appropriate facilities and considerable freedom of work, produce excellent results and develop basic expertise. The second phase included the setting up of the basic experimental facilities at Trombay and the development of requisite know-how and technologies related to all aspects of peaceful uses of atomic energy. It marked the growth of Bhabha Atomic Research Centre (BARC) (earlier known as Atomic Establishment Trombay (AEET)) as the national centre for research and development work in various disciplines of nuclear science and technology. The third phase witnessed the utilization of knowledge and expertise acquired for the economic development of the country through atomic power projects, and setting up of public sector industries based on the technology developed at BARC (Department of Atomic Energy, 1998 and 2004).

INTERNATIONAL NUCLEAR INFORMATION SYSTEM (INIS)

The International Nuclear Information System (INIS) is a cooperative, computerised decentralised information system set up by the International Atomic Energy Agency (IAEA) and its member states in 1970. Its main objective is to provide a comprehensive bibliographic database relating to nuclear science and technology and its peaceful applications (Balakrishnan, 1986; International Atomic Energy Agency, 1987). In 2002 there were 108 countries and 19 international organizations participating in INIS (International Atomic Energy Agency, 2002). India has been participating in the INIS as one of the member countries right from its inception in 1970. Scientific Information Resource Division of BARC is an input centre for India to INIS. It regularly scans the scientific and technical literature published in India falling within the scope of INIS and sends the input to INIS central secretariat, Vienna, Austria in standard formats as prescribed by INIS. Kamath (1976) explained the evolution of information systems in the field of nuclear science and technology with special reference to Scientific Information Resource Division (formerly Library and Information Services Division) of BARC and its role in the development of atomic energy for peaceful purposes in India.

Evaluation is a key component of any research and development activity. One well-known productivity indicator is the number of publications produced by the scientists, institutions and countries. Studies like this will provide some insight into the complex dynamics of research activity and enable the nuclear scientists, policy makers and science administrators to provide adequate facilities and proper guidance in which direction the research has to be conducted. Some scientometric studies in India in some disciplines of science (Gupta, 1980; Begum and Sami, 1986; Karki, 1990; Arunachalam and Urmi, 1998 and 2001; Arunachalam and Rino, 1998) have been carried out. Garg and Dutt (1992) conducted a bibliometric study on Indian science using Science Citation Index and reported that 50% of the contributions were from Council of Scientific and Industrial Research (CSIR) and DAE. Verma, Sharma and Khatri (1982) carried out a study in nuclear research based on the Indian Science Abstracts (1975-1979) and reported that BARC is one of the main contributors. It is seen from the literature that no similar comprehensive study seems to have been carried out on Indian nuclear science and technology.

OBJECTIVES

The main objective of the study is to present the growth of literature and make the quantitative assessment of status of nuclear science and technology research in India by way of analyzing the following features of research output:

- To find out year-wise growth of publications in terms of input of records to INIS database by India and other countries including international organizations,
- To find out the domain-wise contributions,
- To find out authorship and collaboration pattern in the publications,
- To find out the extent of international collaboration,
- To find out language-wise distribution of publications,
- To find out the channels of communications used by the scientists,
- To find out country-wise distribution of journals, and
- To find out the high frequency keywords appeared in indexer assigned-descriptors (DEI).

MATERIALS AND METHODS

The data source for the study was INIS-On disc (CD-ROM), published by the INIS Central Secretariat at IAEA Head Quarters at Vienna, Austria. It is the world's leading abstracting and indexing service providing on all aspects of peaceful applications of Nuclear Science and Technology. By using suitable search strategy, records pertaining to India in the Author affiliation field (INDIA in AU) were downloaded for the years 1970-2002 on 7th July 2003. The database has the open provision to make inputs of records whenever one comes across irrespective of its date of publication. A total of 55313 records were downloaded. The bibliographic details for each record included author, author's affiliation, title, type of document, source of publication, year of publication, keywords, language of the article and country of input. Further all the bibliographic details were transferred to a spreadsheet. The data was analysed as per objectives of the study.

RESULTS AND DISCUSSION

Year-wise Growth of Publications in terms of Input to INIS Database by India and Other Countries

During 33 years period (1970–2002) India has produced a total of 55313 publications. The highest number of publications was 2628 in 1991. The average number of publications per year was 1676.15. Total number of records input to INIS

database by India during 1970-2002 was 30356 (54.88 %). The highest number of records input by India was 1699 in 1993. The average number of publications input per year to INIS by India was 948.63. More number of inputs was made by India during 1979, 1989 and 1991-2000. The total number of publications input by other countries including international organizations was 24957 (45.12%). The highest number of input of publications by other countries was 1183 in 1989. Figure 1 and Table 1 give year-wise growth of Indian publications in nuclear science and technology and number of publications input to INIS database by India and other countries.

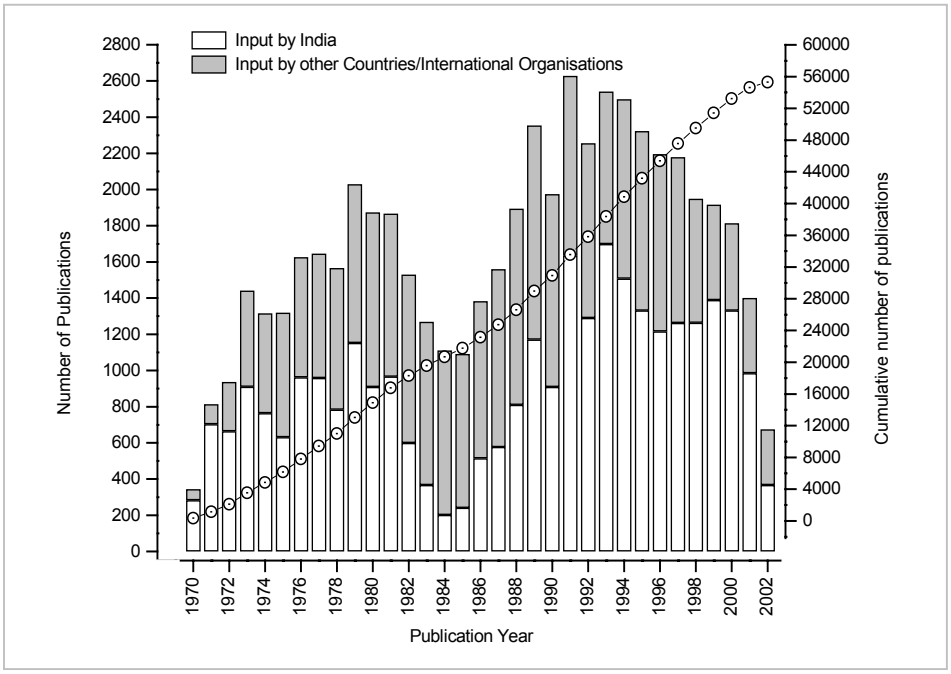

Figure 1: Year-wise Growth of Publications by Indian Scientists in Nuclear Science and Technology in Terms of Input of Publications to INIS (1970-2002) Database by India and Other Countries/International Organizations.

Table 1: Year-wise Distribution of Indian Contribution to Nuclear Science and Technology in Terms of Input by India and Other Countries/ International Organisations to INIS (1970-2002)

Year	Input by India	Input by Other Countries/International Organisations	Total input	Cumulative	Total World Input	Percentage
1970	283	61	344	344	3981	8.64
1971	703	110	813	1157	10408	7.81
1972	664	272	936	2093	20846	4.49
1973	910	531	1441	3534	56614	2.55
1974	764	552	1316	4850	63614	2.07
1975	632	687	1319	6169	63296	2.08
1976	962	664	1626	7795	60478	2.69
1977	958	687	1645	9440	69028	2.38
1978	783	783	1566	11006	70795	2.21
1979	1152	877	2029	13035	75966	2.67
1980	909	965	1874	14909	76599	2.45
1981	966	901	1867	16776	70820	2.64
1982	599	931	1530	18306	72718	2.10
1983	367	902	1269	19575	92216	1.38
1984	202	908	1110	20685	73362	1.51
1985	241	850	1091	21776	86529	1.26
1986	515	868	1383	23159	90401	1.53
1987	577	983	1560	24719	101118	1.54
1988	810	1084	1894	26613	106919	1.77
1989	1171	1183	2354	28967	86281	2.73
1990	909	1065	1974	30941	95604	2.06
1991	1636	992	2628	33569	92012	2.86
1992	1290	966	2256	35825	88990	2.54
1993	1699	842	2541	38366	76577	3.32
1994	1508	991	2499	40865	77107	3.24
1995	1331	991	2322	43187	79021	2.94
1996	1216	979	2195	45382	80854	2.71
1997	1263	916	2179	47561	80899	2.69
1998	1264	685	1949	49510	67994	2.87
1999	1389	527	1916	51426	61398	3.12
2000	1331	482	1813	53239	65768	2.76
2001	985	415	1400	54639	69662	2.01
2002	367	307	674	55313	71306	0.95
Total	30356	24957	55313		2359181	2.34

More number of Indian publications input was made by other countries during 1982-1990. This clearly indicates that Indian nuclear scientists tried to publish more number of publications during this period in international channels of communication. The time-lag between the date of publication and the date of input in the database is roughly about 18 months. It is found from the data that about 70% of total publications published during the particular year are input in 12 months period and the remaining 30% of publications are spread over 2-3 years or more as the database has a open provision for input of records. It is due to this time-lag the number of publications during 2001-2002 are a few in number which may increase after a few months or one year. India's average contribution to the world literature was 2.25% of the total output.

Indian Contribution to Nuclear Science and Technology as per Country of Publication

Indian Nuclear scientists published 30356 (54.88%) publications in Indian channels of communication and preferred to publish 24957 (45.12%) publications outside India. The country wise break-up is given in Table 2. United States published 9.873% publications followed by United Kingdom with 9.381%, Netherlands with 6.152%, Germany with 5.125%, IAEA with 3.455%, Hungary with 2.602%, Japan with 1.226% and Italy with 1.0%.

Table 2: Indian Contribution to Nuclear Science and Technology as per Country of Publication (1970-2002)

Rank	Countries/ International Organisations	No of publications	Cumulative	Percentage
1	India	30356	30356	54.880
2	United-States	5461	35817	9.873
3	United-Kingdom	5189	41006	9.381
4	Netherlands	3403	44409	6.152
5	Germany	2835	47244	5.125
6	IAEA	1911	49155	3.455
7	Hungary	1439	50594	2.602
8	Japan	678	51272	1.226
9	Italy	553	51825	1.000
10	Switzerland	538	52363	0.973
11	France	482	52845	0.871
12	Canada	304	53149	0.550
13	Australia	284	53433	0.513
13	Sweden	284	53717	0.513
14	Poland	247	53964	0.447
15	Brazil	237	54201	0.428
16	Austria	203	54404	0.367
17	Czechoslovakia	142	54546	0.257
18	China	115	54661	0.208
19	Denmark	106	54767	0.192

20	USSR	93	54860	0.168
21	Slovakia	53	54913	0.096
22	Argentina	46	54959	0.083
23	Malaysia	38	54997	0.069
24	Czech-Republic	37	55034	0.067
25	Romania	36	55070	0.065
26	CEC (Commission of the European Communities)	29	55099	0.052
27	Iran-Islamic-Republic-of	20	55119	0.036
27	Israel	20	55139	0.036
27	NEA (Nuclear Energy Agency)	20	55159	0.036
28	Mexico	19	55178	0.034
29	Russian Federation	14	55192	0.025
30	Belgium	12	55204	0.022
31	Ireland	11	55215	0.020
32	Bulgaria	10	55225	0.018
32	Korea-Republic-of	10	55235	0.018
32	UN	10	55245	0.018
33	Egypt	6	55251	0.011
34	Finland	5	55256	0.009
34	IEA (International Energy Agency)	5	55261	0.009
34	Ukraine	5	55266	0.009
35	Cuba	4	55270	0.007
35	Indonesia	4	55274	0.007
35	Pakistan	4	55278	0.007
35	Syrian-Arab-Republic	4	55282	0.007
36	Norway	3	55285	0.005
37	Chile	2	55287	0.004
37	JINR	2	55289	0.004
37	New-Zealand	2	55291	0.004
37	Philippines	2	55293	0.004
37	Singapore	2	55295	0.004
37	Singapore	2	55295	0.004
37	South-Africa	2	55297	0.004
37	Spain	2	55299	0.004
37	Viet-Nam	2	55301	0.004
37	Yugoslavia	2	55303	0.004
38	Bangladesh	1	55304	0.002
38	Costa-Rica	1	55305	0.002
38	Croatia	1	55306	0.002
38	Morocco	1	55307	0.002
38	Norway	1	55308	0.002
38	Sri-Lanka	1	55309	0.002
38	Turkey	1	55310	0.002
38	UNIDO	1	55311	0.002
38	WEC (World Energy Council)	1	55312	0.002
38	XU	1	55313	0.002

Domain-wise Contributions

During 33 years (1970–2002) Indian Nuclear scientists have contributed significantly to the following main domains which have been broadly grouped:

Physics, Chemistry, Engineering and Technology, Life and Environmental Sciences, Other Aspects of Nuclear and Non Nuclear Energy, and Isotopes and Radiation Application. There were 23033 (41.64%) publications in 'Physics' domain followed by 16368 (29.59%) in 'Chemistry', 7203 (13.02%) publications in 'Life and Environmental Sciences', 6960 (12.58%) publications in 'Engineering and Technology', 981 (1.77%) publications in 'Other Aspects of Nuclear and Non Nuclear Energy', and 768 (1.39%) publications in 'Isotopes and Radiation Application'. Year-wise growth of publications in each domain is given in Figure 2.

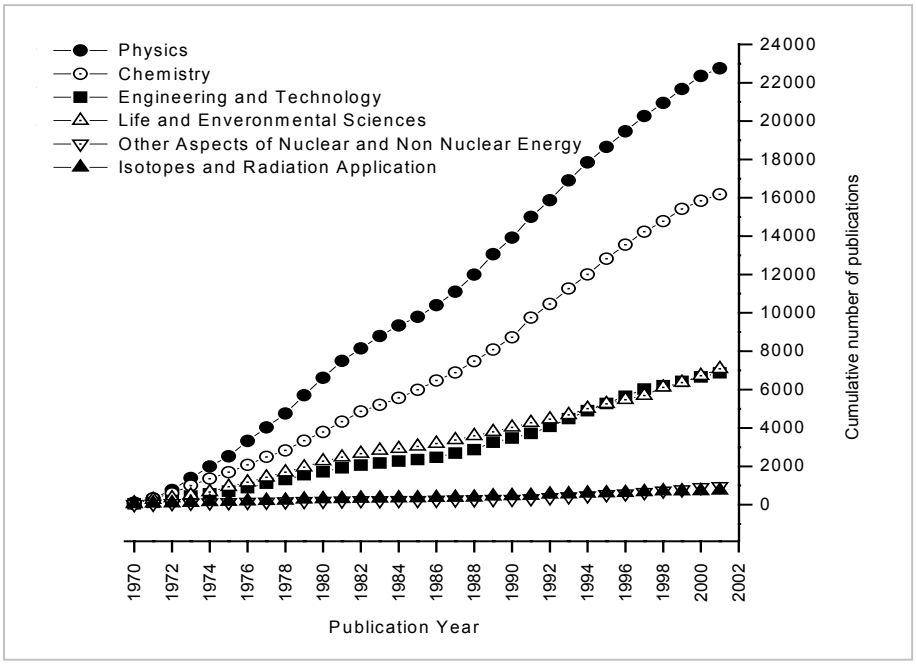

Figure 2: Domainwise Growth of Publications of India's Contributions to Nuclear Science and Technology (1970-2002)

Authorship and Collaboration Pattern

Year-wise authorship and collaboration pattern among Indian nuclear scientists is given in Figure 3 and Table 3. Authorship trend is towards multi-authored papers. Two authored papers account for 32.28% followed by three authored papers 23.71%, single authored papers 17.4%, four authored papers 12.8% and five authored papers 6.66%. It can be clearly visualised from the Table 3 that 11 papers

were with more than sixty authors during 1971–1975. During 1984 –1999 the collaboration trend was more intensified as more than 163 papers were with more than twenty collaborators, out of which 14 papers were with more than 100 collaborators. One paper, '*Nuclear Instruments and Methods in Physics Research* – A325, (1993) 23-91' had 163 collaborators. Collaboration coefficient was more during 1979–1997.

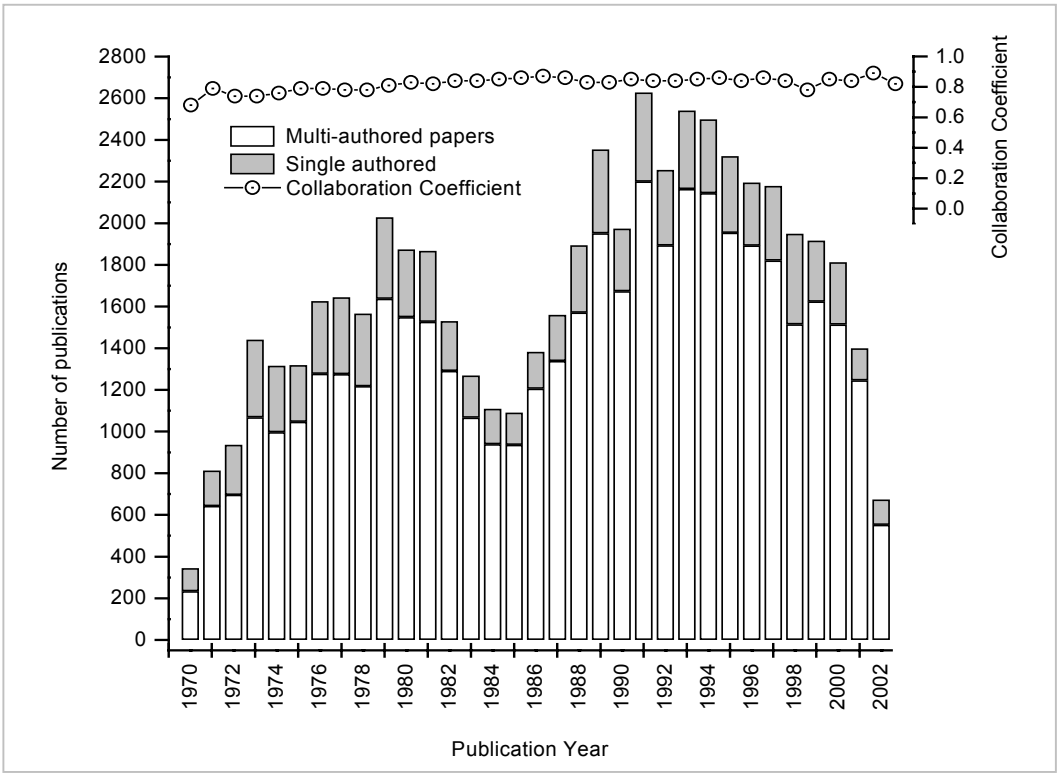

Figure 3: Yearwise Productivity, Collaboration and Collaboration Coefficient in the Publications in Nuclear Science and Technology (1970-2002)

Table 3: Authorship and Collaboration Trend in Nuclear Science and Technology (1970-2002)

Year	Number of papers under various Authorships																						Total
	1	2	3	4	5	6	7	8	9	10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-110	111-120	121-130	163	
1970	110	133	66	17	9	6	1		2															344
1971	170	325	197	63	28	14	9	4	1	1	1													813
1972	239	376	198	66	30	18	2	3		1	2							1						936
1973	372	564	309	123	39	12	11	3	2	1	1					1		3						1441
1974	319	550	287	94	38	11	6	1		1	4						3	2						1316
1975	272	590	286	114	36	12	4	4										1						1319
1976	348	636	406	155	54	17	3	2	3		2													1626
1977	369	687	362	146	46	19	8	1	2		5													1645
1978	348	633	337	141	61	18	9	8	3		8													1566
1979	391	782	507	205	89	29	15	4	3	3	1													2029
1980	325	777	478	180	69	23	11	4	6	1														1874
1981	340	735	468	199	77	25	10	6	5	2														1867
1982	239	581	410	165	76	28	20	6	4	1														1530
1983	202	523	304	143	60	22	7	2	4		2													1269
1984	170	440	272	129	50	24	7	4	6	1	3	2		2										1110
1985	155	421	294	117	59	25	7	5	1		1	3	1	2										1091
1986	177	510	367	167	77	43	19	9	6	1	1	3		2		1								1383
1987	221	509	419	200	104	42	30	14	7		1	1	2	5	2	1			1	1				1560
1988	323	634	445	250	122	50	34	15	8		6	3	2	1			1							1894
1989	402	725	599	319	154	69	32	21	14	4	3	2		2	3		2	2	1					2354
1990	300	665	471	245	147	52	31	22	6	11	12	3	2	1			2	1	2	1				1974
1991	428	729	636	394	220	95	61	26	14	8	9	1		1		1		1	1	1		2		2628
1992	362	647	547	338	191	66	43	29	10	3	10	1	1			1	2	1	1	1	2			2256
1993	377	687	577	415	239	100	59	32	27	7	14	2				2				1	1		1	2541
1994	354	681	637	390	204	100	52	26	23	8	19	2	1				1		1					2499
1995	368	596	534	354	227	112	51	27	25	6	17	2	1	1								1		2322
1996	302	566	475	368	195	121	64	30	27	19	19	5	1		2		1							2195
1997	358	515	527	328	203	96	53	40	13	16	17	2			1			8	2					2179
1998	434	409	393	282	183	86	59	28	22	10	23		1		1			16	1	1				1949
1999	292	450	438	291	187	102	61	39	20	11	10	1	1	1		1	6	4		1				1916
2000	299	402	389	311	157	110	71	27	16	17	14													1813
2001	154	253	333	272	172	98	56	31	12	6	13													1400
2002	122	125	146	116	80	42	21	4	9	4	5													674
Total	9642	17856	13114	7097	3683	1687	927	477	301	143	223	33	13	18	9	8	18	40	10	7	3	3	1	55313
%	17.4	32.28	23.71	12.8	6.66	3.05	1.7	0.9	0.5	0.3	0.4	0.1	0.02	0.03	0.02	0.01	0.03	0.1	0.02	0.01	0.01	0.01	0.002	100

International Collaboration

In recent years, every country has realised the importance of scientific research for its growth and started initiating programmes which makes scientists to have more interactions with other scientists, both at national and international levels. Table 4 provides India's international collaboration pattern in Nuclear Science and

Technology. Table 5 provides India's International collaboration with publications more than five and Tables 6 – 9 provide India's International collaboration with four, three, two and single publications respectively. Bilateral collaboration accounts for 80.06% of total international collaborative publications followed by trilateral collaboration with 12.35% and quadrilateral collaboration with 3.68%. India has highest number of bilateral collaborative publications (476) with United States followed by Italy with 381 papers, Germany with 243 papers, France with 187 papers, Japan with 186 papers, United Kingdom with 130 papers and Canada with 117 papers.

Table 4: International Collaboration Pattern of Indian Contribution in Nuclear Science and Technology (1970-2002)

Number of Countries	Number of Publications	Percentage
Two	2373	80.06
Three	366	12.35
Four	109	3.68
Five	28	0.94
Six	38	1.28
Seven	22	0.74
Eight	9	0.30
Nine	4	0.13
Ten	12	0.40
Eleven	2	0.07
Twelve	1	0.03
Total	2964	100

Table 5: International Collaboration in Nuclear Science and Technology (1970-2002)

Sl. No.	Countries and International Organisations	Number of Collaborative Papers	Sl. No.	Countries and International Organisations	Number of Collaborative Papers
1	India-United States	476	32	India-Romania	11
2	India-Italy	381	33	India-Brazil-Colombia-France-Argentina-Korea, Republic of-Mexico Poland-Russian Federation-United States	10
3	India-Germany	243	34	India-Finland	10
4	India-France	187	35	India-Germany-Poland	10
5	India-Japan	186	36	India-Egypt	9
6	India-United Kingdom	130	37	India-Korea, Republic of	9
7	India-Canada	117	38	India-Hungary-Bulgaria-Poland-Romania	8

8	India-Brazil	75	39	India-Canada-United States	8
9	India-Switzerland	71	40	India-Finland-Sweden	8
10	India-Australia	55	41	India-France-United States	8
11	India-Sweden	49	42	India-Iraq	8
12	India-Netherlands	34	43	India-Greece	7
13	India-Russian Federation	27	44	India-Israel	7
14	India-Brazil-Colombia-Argentina-Mexico-United States	25	45	India-Spain-Switzerland	7
15	India-Austria	24	46	India-China-Sweden	6
16	India-Denmark	23	47	India-Hungary-Germany	6
17	India-Hungary	21	48	India-Germany-Netherlands	6
18	India-United Kingdom-United States	20	49	India-Sweden-United States	6
19	India-Belgium	19	50	India-Syrian Arab Republic	6
20	India-Italy-United States	19	51	India-Indonesia	6
21	India-Bangladesh	17	52	India-Brazil-Italy	5
22	India-China	17	53	India-China-Japan	5
23	India-Brazil-Russian Federation-United States	15	54	India-China-United States	5
24	India-Belgium-Switzerland-Spain-Austria-Italy-Japan	14	55	India-France-Italy	5
25	India-Poland	14	56	India-United Kingdom-France	5
26	India-Spain	14	57	India-France-Germany	5
27	India-Germany-United States	13	58	India-IAEA	5
28	India-Japan-United States	13	59	India-South Africa	5
29	India-Nigeria	13	60	India-Viet Nam	5
30	India-Papua New Guinea	13	61	India-Spain-Italy	5
31	India-Mexico	11			

Table 6: International Collaboration in Nuclear Science and Technology (1970-2002) with Four Papers Each

India-Algeria; India-Austria-Japan; India-Bahrain; India-Canada-Belgium; India-Brazil-United States; India-Czechoslovakia; India-France-Morocco; India-Germany-Italy-United States; India-Russian Federation-United States; India-Germany-Switzerland; India-Switzerland-United States.

Table 7: International Collaboration in Nuclear Science and Technology (1970-2002) with Three Papers Each

India-Canada-France-Argentina-Poland; India-France-Argentina-Poland; India-Argentina; India-Canada-China-Germany-Armenia-Kazakhstan-Sweden- United States-Uzbekistan; India-Australia-United States; India-United Kingdom-Australia; India-Austria-United States; India-Switzerland-Austria-Poland; India-France-Brazil; India-Bulgaria; India-France-China-Sweden;

India-Germany-China; India-China-Italy; India-Denmark-Sweden; India-France-Ukraine; India-Israel-France; India-Greece-Germany; India-Hungary-Germany-United States; India-Germany-Japan; India-Germany-Japan-Russian Federation; India-Germany-South Africa; India-United Kingdom-Germany; India-Hungary-United States; India-Libyan Arab Jamahiriya; India-Malaysia; India-Monaco; India-Nepal; India-New Zealand; India-Poland-United States; India-Turkey; India-Ireland; India-United Kingdom-Japan

Table 8: International Collaboration in Nuclear Science and Technology (1970-2002) with Two Papers Each

India-Algeria-Saudi Arabia; India-Australia-Japan; India-Belgium-Switzerland-Austria; India-Germany-Austria; India-United Kingdom-Austria-United States; India-Bangladesh-Italy; India-Belgium-Netherlands; India-Switzerland-Spain-France-Belgium-Italy-Sweden; India-France-Brazil-Japan-United States; India-China-Canada-Sweden; India-Germany-Canada; India-Germany-Canada-Japan-Korea, Republic of-Russian Federation; India-Germany-United Kingdom-Canada; India-Canada-Korea, Republic of; India-Spain-Chile; India-China-Japan-Korea, Republic of; India-Finland-Denmark; India-France-Finland; India-France-Italy-United States; India-France-Poland; India-United Kingdom-France-United States; India-Finland-Germany; India-Germany-CERN; India-Germany-Italy; India-United Kingdom-Germany-United States; India-CERN; India-Iran, Islamic Republic of; India-Italy-Japan; India-Italy-Japan-United States; India-Italy-Mexico; India-Italy-Poland; India-Japan-Poland; India-Malaysia-United States; India-Netherlands-United States; India-Pakistan; India-Philippines; India-Poland-Romania; India-Poland-Sweden-United States; India-Tunisia; India-Turkey-United States; India-Germany-Switzerland-Netherlands-Russian Federation-Sweden-United States; India-Switzerland-Italy; India-Switzerland-Japan; India-Switzerland-Netherlands; India-United Kingdom-Switzerland; India-United Kingdom-Switzerland-Italy; India-United Kingdom-Italy; India-United Kingdom-Mexico.

Table 9: International Collaboration in Nuclear Science and Technology (1970-2002) with Single Paper Each

India-Brazil-China-Colombia-Ecuador-France-Argentina-Korea, Republic of-Mexico-Poland-Russian Federation; India-France-Argentina-Japan-Sweden; India-Germany-Argentina; India-Argentina-United States; India-Israel-Argentina-Sweden; India-Australia-China-Germany-Armenia-Kazakhstan-Russian Federation-Sweden-United States-Uzbekistan-JINR; India-Canada-China-Czechoslovakia-Germany-Armenia-Kazakhstan-Sweden-United States-Uzbekistan; India-Armenia; India-Brazil-Germany-Australia-United States; India-Canada-Australia; India-Canada-Australia-New Zealand; India-Canada-Spain-Finland-Australia-Poland-United States; India-China-Germany-Australia-Mexico; India-China-Australia-United States; India-Denmark-Australia; India-Australia-Kazakhstan-Russian Federation; India-Australia-Korea, Republic of; India-Australia-New Zealand; India-Australia-Sweden; India-Israel-Australia-United States; India-Australia-Germany-France-United Kingdom-Austria-Japan-Russian Federation; India-Belgium-Brazil-Switzerland-Germany-Spain-France-United Kingdom-Austria-Italy-Japan-Sweden; India-Belgium-Brazil-Switzerland-Spain-France-Austria-Italy-Japan-Sweden; India-Belgium-Austria-Italy-Netherlands; India-Belgium-Spain-Austria-Italy-Japan; India-Belgium-Switzerland-Spain-France-Austria-Italy-Sweden; India-Belgium-Switzerland-Spain-Austria-Italy-Japan-Netherlands; India-Belgium-Switzerland-Spain-Austria-Italy-Japan-Romania; India-Brazil-

France-Austria-Puerto Rico; India-Brazil-Germany-Austria-United States; India-Canada-Austria-Portugal; India-China-Austria-Japan-United States; India-France-Austria; India-Germany-France-Austria; India-Austria-Italy; India-Austria-Peru-Slovenia; India-Switzerland-Spain-France-Austria-Norway-Poland; India-Belarus; India-China-Belgium; India-France-Belgium; India-Germany-Belgium; India-Germany-Belgium-Russian Federation; India-Belgium-Japan; India-Belgium-Poland; India-Belgium-United States; India-Switzerland-Germany-France-Belgium-Italy-Romania-Russian Federation; India-Switzerland-Germany-France-United Kingdom-Belgium-United States; India-Switzerland-Germany-United Kingdom-Belgium-United States; India-Switzerland-Spain-France-Belgium-Italy-Japan-Sweden; India-Switzerland-United Kingdom-Belgium-Russian Federation-United States; India-United Kingdom-Belgium-Italy; India-Botswana; India-Canada-Brazil-Italy; India-Canada-Brazil-Italy-United States; India-Germany-Brazil-United States; India-Hungary-Brazil; India-Brazil-Italy-United States; India-Brazil-Japan; India-Brazil-Mexico; India-Brazil-Russian Federation; India-Brazil-Sweden-United States; India-Switzerland-Brazil; India-Germany-Bulgaria-Poland; India-Germany-Bulgaria-Poland-United States; India-Denmark-Finland-Canada; India-France-Canada-United States; India-Canada-Italy; India-Canada-Italy-United States; India-Canada-Netherlands; India-Canada-Sweden; India-Spain-Canada; India-Switzerland-Spain-Canada; India-United Kingdom-Canada; India-United Kingdom-Canada-United States; India-France-Chile; India- Czechoslovakia-China-Kazakhstan-Russian Federation-Sweden-United States-JINR; India-Czechoslovakia-China-United States; India-Denmark-China; India-France-China-United States; India-Germany-France-Hungary-China-Italy-Romania-United States; India-Germany-China-Russian Federation; India-Germany-Israel-China-Italy-Russian Federation; India-Germany-Spain-China; India-China-Philippines; India-China-Russian Federation-United States; India-United Kingdom-Cyprus; India-Czechoslovakia-Sweden; India-Denmark-Japan; India-Denmark-United States; India-Hungary-Egypt; India-Ethiopia; India-Finland-United States; India-Hungary-France-Sweden; India-France-Japan-Netherlands; India-France-Nigeria; India-France-Poland-United States; India-France-Sweden; India-France-United States-Yugoslavia; India-France-Viet Nam; India-France-Yugoslavia; India-Ireland-France; India-United Kingdom-France-Russian Federation; India-Georgia-Ukraine; India-Denmark-France-Germany; India-Denmark-Germany-Italy-United States; India-Denmark-United Kingdom-Germany-Sweden-United States; India-Finland-Germany-United States; India-France-Greece-Germany-Russian Federation-United States; India-France-Germany-Italy; India-France-Germany-Italy-Sweden-United States; India-France-Germany-Sweden; India-France-Germany-Ukraine; India-France-United Kingdom-Germany-Netherlands- United States; India-Germany-Italy-Japan; India-Germany-Italy-Japan-Netherlands; India-Germany-Lithuania-Poland; India-Germany-Mexico-United States; India-Germany-Portugal; India-Germany-Romania; India-Germany-Romania-United States; India-Germany-Russian Federation; India-Spain-Germany; India-United Kingdom-Greece-Germany; India-United Kingdom-Germany-Poland; India-Ghana; India-Guatemala-Kenya-Netherlands-Thailand; India-Honduras-United States; India-Hungary-Poland-Romania; India-Italy-Netherlands; India-Italy-Russian Federation; India-Italy-South Africa; India-Italy-Yugoslavia; India-Jamaica; India-Japan-Korea, Republic of; India-Japan-Korea, Republic of-Russian Federation-United States; India-Japan-Korea, Republic of-United States; India-Japan-Nepal; India-Japan-Portugal; India-Japan-Russian Federation-United States; India-Korea, Republic of-United States; India-Kuwait; India-Mexico-Puerto Rico; India-Netherlands-Romania; India-Norway-United States; India-Portugal; India-Puerto Rico; India-Saudi Arabia; India-Sri Lanka; India-Sri Lanka-Pakistan-Thailand; India-Sudan; India-Taiwan, Province of China; India-Ukraine; India-Uzbekistan; India-Venezuela; India-Yugoslavia; India-Ireland-Italy; India-Ireland-Poland; India-Israel-Italy; India-Israel-Netherlands-Yugoslavia; India-Israel-United States; India-United States-Korea, Republic of; India-Spain-Italy-Russian Federation; India-Spain-Korea, Republic of; India-United Kingdom-Spain; India-United States-Sweden; India-China-Germany-Switzerland-Pakistan-Russian Federation; India-China-Switzerland-Italy; India-France-Switzerland; India-France-United

Kingdom-Croatia-Switzerland-Portugal-Russian Federation-CERN; India-Germany-France-Switzerland-Italy-Romania-Russian Federation-Sweden-United States; India-Germany-France-Switzerland-Russian Federation-United States; India-Germany-Switzerland-Japan; India-Germany-Switzerland-Netherlands-Poland-Sweden; India-Germany-Switzerland-Norway-Sweden; India-Germany-Switzerland-Russian Federation-United States; India-Germany-Spain-France-Hungary-Switzerland-Italy; India-Switzerland-Italy-CERN; India-Switzerland-Poland; India-Switzerland-Russian Federation; India-United Kingdom-Italy-Netherlands; India-United Kingdom-Japan-United States; India-United Kingdom-Netherlands; India-United Kingdom-Poland-United States; India-United Kingdom-Portugal; India-United Kingdom-Russian Federation; India-United Kingdom-South Africa

Language-wise Distribution of Publications

Table 10 depicts the language-wise distribution of publications from all over the world as well as from India. English has topped the list with 55109 (99.631%) publications, followed by Russian with 72 (0.130%) publications, German with 52 (0.094%) publications, and Hindi with 27 (0.049%) publications. Indian nuclear scientists have contributed predominantly in English with a few exceptions. The publications in other foreign languages are mainly due to collaboration with respective foreign institutions. Amongst Indian languages Hindi figured during 1970 – 1993. No publications in Hindi were reported in the database after 1993.

Table 10: Language-wise Distribution of Indian contribution in Nuclear Science and Technology (1970 - 2002)

Rank	Language	Number of publications	Percentage	Rank	Language	Number of publications	Percentage
1	English	55109	99.631	9	Arabic	4	0.007
2	Russian	72	0.130	10	Japanese	3	0.005
3	German	52	0.094	11	Hungarian	2	0.004
4	Hindi	27	0.049	11	Spanish	2	0.004
5	German; English	13	0.024	12	Czech	1	0.002
6	French	12	0.022	12	Persian	1	0.002
7	French; English	7	0.013	12	Polish	1	0.002
8	Portuguese	6	0.011	12	Serbo-Croat	1	0.002
Total						**55313**	**100**

Preference of Channels of Communication by Indian Nuclear Scientists

Figure 4 depicts that more than 60% of the Indian Nuclear Science and Technology research was published in journals and the rest was in books/conferences (28.40%), Reports (6.82%), Computer Media (0.07%) and Miscellaneous (4.06) channels of communication.

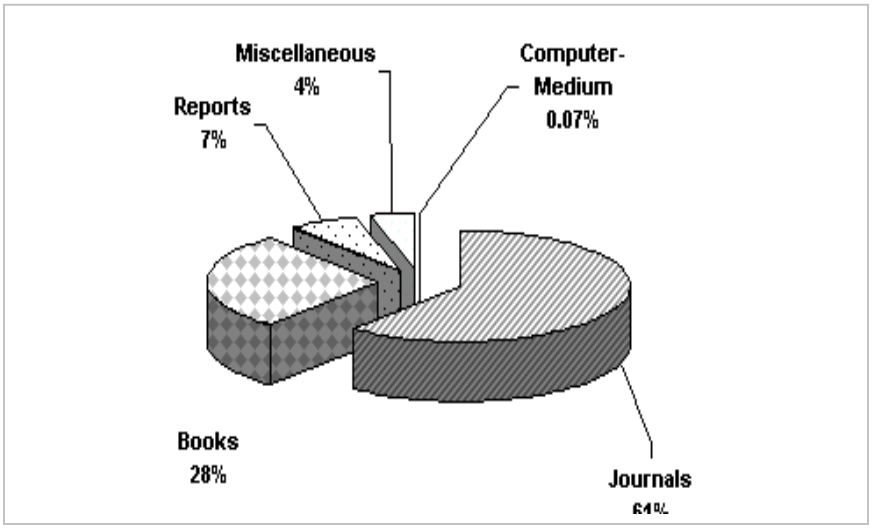

Figure 4: Types of Channels of Communication used by Indian Nuclear Scientists (1970-2002)

The leading journals preferred by the scientists were *Pramana* with 1327 (3.95%) papers, *Indian Journal of Pure and Applied Physics* with 1104 (3.29%) papers, *Physical Review–D* with 925 (2.75%) papers, *Journal of the Indian Chemical Society* with 783 (2.33%) papers and *Indian Journal of Chemistry-A* with 734 (2.19%) papers. Table 11 provides the top 134 journals, which have published 50 or more articles and Figure 5 provides year-wise distribution of top five journals.

Table 11: Journals Most Preferred by the Indian Nuclear Scientists

Rank	Journal	Country of Publication	Number of Papers	%	IF 2003
1	Pramana	India	1327	3.95	0.33
2	Indian-Journal-of-Pure-and-Applied-Physics	India	1104	3.29	0.37
3	Physical-Review-D	USA	925	2.75	4.6
4	Journal-of-the-Indian-Chemical-Society	India	783	2.33	0.28
5	Indian-Journal-of-Chemistry-Section-A	India	734	2.19	0.49
6	Physical-Review-C	USA	697	2.08	2.71
7	Current-Science	India	615	1.83	0.69
8	Indian-Journal-of-Physics-Part-A	India	587	1.75	-
9	Bulletin-of-Radiation-Protection	India	563	1.68	-
10	Journal-of-Radioanalytical-and-Nuclear-Chemistry	Hungary	502	1.49	0.47
11	Journal-of-Nuclear-Agriculture-and-Biology	India	489	1.46	-

Rank	Journal	Country of Publication	Number of Papers	%	IF 2003
12	Journal-of-physics-G	UK	487	1.45	1.35
13	Physics-Letters-B	Netherlands	435	1.30	4.07
14	Physical-Review-A	USA	366	1.09	2.59
15	Indian-Journal-of-Physics-Part-B	India	364	1.08	-
16	Journal-of-physics-B	UK	347	1.03	1.72
17	Physica-Status-Solidi-B	Germany	343	1.02	0.99
18	Physica-Status-Solidi-A	Germany	340	1.01	0.95
19	Bulletin-of-Materials-Science	India	329	0.98	0.53
20	Journal-of-Nuclear-Materials	Netherlands	309	0.92	1.18
21	Physical-Review-B	USA	297	0.88	2.96
22	Journal-of-Medical-Physics	India	296	0.88	-
23	Radiation-Protection-and-Environment	India	272	0.81	-
24	Nuclear-Physics-A	Netherlands	271	0.81	1.76
25	Journal-of-physics-A	UK	267	0.80	1.36
26	Journal-of-physics-C	UK	261	0.78	-
27	Journal-of-Radioanalytical-and-Nuclear-Chemistry-Letters	Hungary	260	0.77	-
28	Indian-Journal-of-Experimental-Biology	India	259	0.77	-
29	Astrophysics-and-Space-Science	Netherlands	254	0.76	0.52
30	Radiochimica-Acta	Germany	253	0.75	0.94
31	Radiochemical-and-Radioanalytical-Letters	Hungary	246	0.73	-
32	Physics-Letters-A	Netherlands	230	0.68	1.32
33	Proceedings-of-the-Indian-National-Science-Academy-Part-A	India	224	0.67	-
34	Journal-of-Radioanalytical-and-Nuclear-Chemistry-Articles	Hungary	202	0.60	-
35	Monthly-Notices-of-the-Royal-Astronomical-Society	UK	200	0.60	4.99
36	Radiation-Physics-and-Chemistry	UK	194	0.58	0.69
37	Nuclear-Instruments-and-Methods-in-Physics-Research	Netherlands	193	0.57	-
38	Hyperfine-Interactions	Switzerland	192	0.57	0.44
39	Asian-Journal-of-Chemistry	India	191	0.57	0.21
40	Physical-Review-Letters	USA	190	0.57	7.04
41	Canadian-Journal-of-Physics	Canada	189	0.56	0.78
42	Physica-Scripta	Sweden	183	0.54	0.69
43	Nuclear-Physics-B	Netherlands	179	0.53	5.3
44	Nuclear-Instruments-and-Methods-in-Physics-Research-Section-A	Netherlands	173	0.52	1.17
45	Zeitschrift-fuer-Physik-A	Germany	170	0.51	-
46	Zeitschrift-fuer-Physik-C	Germany	166	0.49	-
47	Indian-Journal-of-Physics-and-Proceedings-of-the-Indian-Association-for-the-Cultivation-of-Science	India	164	0.49	-
48	Transactions-of-the-Indian-Institute-of-Metals	India	163	0.49	0.07
49	Applied-Radiation-and-Isotopes	USA	157	0.47	0.69
49	Journal-of-the-Geological-Society-of-India	India	157	0.47	0.3
50	Journal-of-Applied-Physics	USA	151	0.45	2.17
51	Nuovo-Cimento-A	Italy	144	0.43	-
52	Journal-of-Inorganic-and-Nuclear-Chemistry	UK	143	0.43	-
52	Physica-B-Condensed-Matter	Netherlands	143	0.43	0.91
53	Annals-of-Nuclear-Energy	UK	141	0.42	0.47

Rank	Journal	Country of Publication	Number of Papers	%	IF 2003
54	Indian-Journal-of-Radio-and-Space-Physics	India	139	0.41	-
55	Radiation-Protection-Dosimetry	UK	135	0.40	0.62
56	International-Journal-of-Applied-Radiation-and-Isotopes	UK	133	0.40	-
57	Journal-of-Radioanalytical-Chemistry	Hungary	129	0.38	-
58	Indian-Journal-of-Chemistry	India	127	0.38	-
58	Journal-of-the-Physical-Society-of-Japan	Japan	127	0.38	1.9
59	Indian-Journal-of-Theoretical-Physics	India	126	0.38	-
59	Journal-of-physics-D	UK	126	0.38	1.27
59	National-Academy-Science-Letters	India	126	0.38	0.07
59	Nuovo-Cimento-B	Italy	126	0.38	0.29
60	Radiation-Effects	UK	121	0.36	-
61	Indian-Journal-of-Radiology-and-Imaging	India	120	0.36	-
62	Lett-Nuovo-Cim	Italy	118	0.35	-
63	Indian-Journal-of-Nuclear-Medicine	India	116	0.35	-
64	Journal-of-Plasma-Physics	UK	115	0.34	0.61
65	Health-Physics	USA	111	0.33	0.78
65	Indian-Journal-of-Pure-and-Applied-Mathematics	India	111	0.33	0.13
66	Crystal-Research-and-Technology	Germany	110	0.33	0.65
66	Nuclear-Tracks-and-Radiation-Measurements	UK	110	0.33	-
66	Physics-of-Plasmas	USA	110	0.33	2.15
67	Proceedings-of-the-Indian-Academy-of-Sciences-Chem-Sci.	India	107	0.32	0.65
68	Proceedings-of-the-Indian-Academy-of-Sciences-Section-A	India	106	0.32	-
69	Superconductor-Science-and-Technology	UK	100	0.30	2.25
70	AMPI-Association-of-Medical-Physicists-of-Indian-Medical-Physics-Bulletin	India	98	0.29	-
70	Nuclear-Instruments-and-Methods-in-Physics-Research-Section-B	Netherlands	98	0.29	1.04
70	Physics-News	India	98	0.29	-
71	Astrophysical-Journal	USA	97	0.29	6.6
72	Talanta	UK	94	0.28	2.09
73	Modern-Physics-Letters-A	USA	93	0.28	1.59
74	Nuclear-Engineering-and-Design	Netherlands	92	0.27	0.42
74	Progress-of-Theoretical-Physics	Japan	92	0.27	2.19
75	Nature	UK	91	0.27	31
76	Transactions-of-the-SAEST	India	90	0.27	-
77	Australasian-Radiology	Australia	87	0.26	-
77	Journal-of-Mathematical-Physics	USA	87	0.26	1.48
78	Indian-Journal-of-Radiology	India	84	0.25	-
79	Czechoslovak-Journal-of-Physics	Czech-Republic	83	0.25	0.26
80	Exploration-and-Research-for-Atomic-Minerals	India	82	0.24	-
81	Acta-Physica-Polonica-Series-B	Warsaw	81	0.24	0.75
81	Journal-of-Geophysical-Research	USA	81	0.24	2.99
81	Strahlentherapie-Germany	Germany	81	0.24	-
82	Science-and-Culture	India	80	0.24	-
83	International-Journal-of-Theoretical-Physics	USA	79	0.24	0.48
83	Radiobiologia-Radiotherapia	Germany	79	0.24	-

Rank	Journal	Country of Publication	Number of Papers	%	IF 2003
83	Solid-State-Communications	UK	79	0.24	1.6
84	Indian-Journal-of-Technology	India	77	0.23	-
84	Physica-B-+-C	Netherlands	77	0.23	-
85	Indian-Journal-of-Biochemistry-and-Biophysics	India	75	0.22	0.25
86	Australian-Journal-of-Physics	Australia	73	0.22	-
86	Journal-of-Materials-Science-Letters	UK	73	0.22	0.47
87	Journal-of-Magnetism-and-Magnetic-Materials	Netherlands	71	0.21	0.91
88	General-Relativity-and-Gravitation	USA	68	0.20	1.21
88	Indian-Journal-of-Environmental-Protection	India	68	0.20	-
88	Journal-of-High-Energy-Physics	Italy	68	0.20	6.06
89	Monatshefte-fuer-Chemie	Austria	67	0.20	0.89
90	Annals-of-Physics	USA	66	0.20	2.53
90	Electrical-India	India	66	0.20	-
90	Materials-Science-Forum	Switzerland	66	0.20	0.6
91	Separation-Science-and-Technology	USA	65	0.19	0.89
92	Journal-of-Scientific-and-Industrial-Research	India	62	0.18	0.19
93	Bulletin-of-Electrochemistry	India	61	0.18	0.24
93	Plasma-Physics-and-Controlled-Fusion	UK	61	0.18	2.82
93	Proceedings-National-Academy-of-Sciences-Indian-Section-A	India	61	0.18	-
93	Transactions-of-the-Indian-Ceramic-Society	India	61	0.18	-
94	Acta-Physica-Polonica-Series-A	Warsaw	60	0.18	0.47
94	Indian-Journal-of-Cancer	India	60	0.18	-
95	International-Journal-of-Modern-Physics-A	USA	59	0.18	0.91
95	International-Journal-Radiat-Biol-Relat-Stud-Phys-Chem-Med	UK	59	0.18	-
96	Mikrochimica-Acta	Austria	56	0.17	-
96	Nuclear-India	India	56	0.17	-
97	Indian-Journal-of-Agricultural-Science	India	55	0.16	-
97	Modern-Physics-Letters-B	USA	55	0.16	0.46
98	Physics-of-Fluids	USA	54	0.16	1.57
99	Acta-Ciencia-Indica-Chemistry	India	52	0.15	-
99	Journal-of-Materials-Science	UK	52	0.15	0.83
99	Nuclear-Geophysics	UK	52	0.15	-
100	Hadronic-Journal	USA	51	0.15	-
100	Nuclear-Tracks	UK	51	0.15	-
101	Indian-Journal-of-Medical-Research	India	50	0.15	0.45
101	Proceedings-of-the-National-Academy-of-Sciences-Indian-A	India	50	0.15	-
					truncated

IF = Impact Factor (SCI-2003)

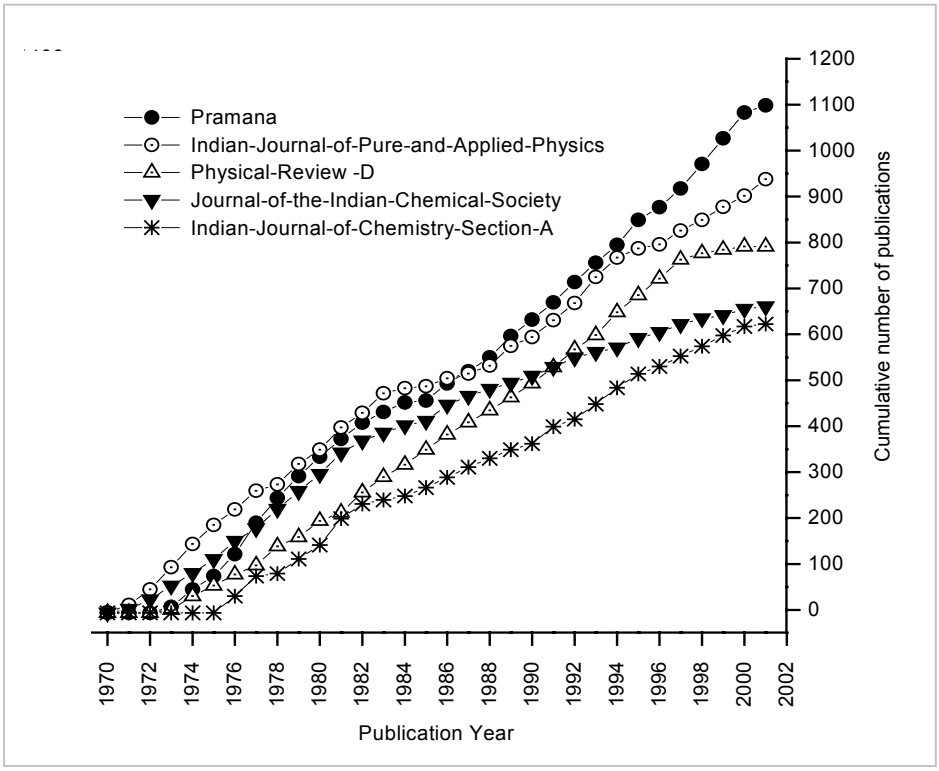

Figure 5: Year-wise Growth of Publications in Five Most Preferred Journals

Indian Contribution in Journals as per Country of Publication

Table 12 provides Indian contribution in journals as per country of publication. Indian Nuclear scientists published their 13290 (39.574%) papers in 355 Indian journals Table-12. The prominent journals published by foreign countries where Indian scientists preferred to publish their papers were United States with 5167 (15.386%) papers in 237 journals followed by United Kingdom with 4746 (14.132%)papers in 228 journals, Netherlands with 3074 (9.153%)papers in 90 journals, 2611 (7.775%) papers in 121 journals, Hungary with 1415 (4.213%) papers in 20 journals, Italy with 537 (1.599%) papers in 15 journals, Switzerland with 504 (1.501%) papers in 25 journals and Japan with 492 (1.465%) papers in 47 Journals.

Table 12: Indian Contribution in Journals as per Country of Publication

Country of Publication	Number of articles	Number of Journals	Percentage	Average
India	13290	355	39.574	37.44
USA	5167	237	15.386	21.8
UK	4746	228	14.132	20.82
Netherlands	3074	90	9.153	34.16
Germany	2611	121	7.775	21.58
Hungary	1415	20	4.213	70.75
Italy	537	15	1.599	35.8
Switzerland	504	25	1.501	20.16
Japan	492	47	1.465	10.47
Sweden	238	4	0.709	59.5
Austria	218	12	0.649	18.17
Canada	212	10	0.631	21.2
France	200	31	0.596	6.45
Australia	181	11	0.539	16.45
Warsaw	141	2	0.42	70.5
Denmark	88	16	0.262	5.5
Czechoslovakia	88	6	0.262	14.67
Czech-Republic	86	2	0.256	43
Poland	77	13	0.229	5.92
USSR	61	20	0.182	3.05
Romania	26	3	0.077	8.67
Brazil	23	7	0.068	3.29
Malaysia	18	4	0.054	4.5
Stockholm	17	1	0.051	17
Ireland	11	5	0.033	2.2
Belgium	8	4	0.024	2
Slovakia	6	2	0.018	3
Republic-of-Korea	4	3	0.012	1.33
Bulgaria	4	2	0.012	2
Indonesia	4	2	0.012	2
Israel	4	2	0.012	2
Syrian Arab Republic	4	1	0.012	4
Norway	3	3	0.009	1
Ukraine	3	2	0.009	1.5
Pakistan	2	2	0.006	1
Philippines	2	2	0.006	1
Russian Federation	2	2	0.006	1
South-Africa	2	2	0.006	1
China	2	1	0.006	2
Havana	2	1	0.006	2
Kansas	2	1	0.006	2
Argentina	1	1	0.003	1

Bangladesh	1	1	0.003	1
Costa-Rica	1	1	0.003	1
Minnesota	1	1	0.003	1
Sri-Lanka	1	1	0.003	1
Turkey	1	1	0.003	1
Viet-Nam	1	1	0.003	1
Yugoslavia	1	1	0.003	1
Total	33583	1325	100	

Distribution of Keywords

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 Figure 6 provides year-wise growth of top five keywords and Table 13 gives a list of high frequency keywords appeared more than 600 times.

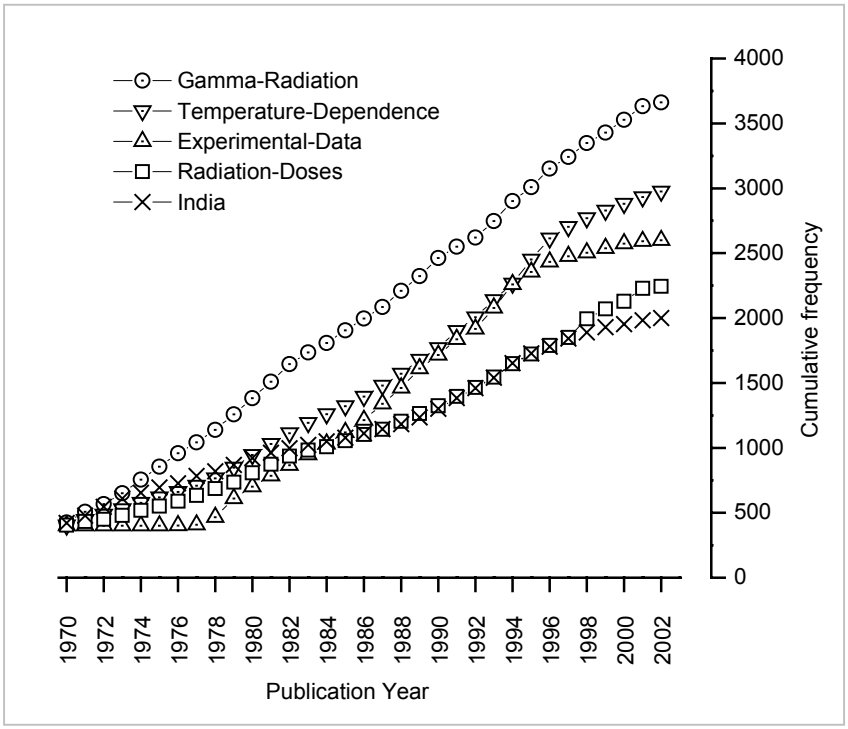

Figure 6: Five Most Frequently Appeared Keywords in Indexer Assigned Descriptors (DEI) in INIS 1970-2002

Table 13: Keywords with more than 600 frequencies Appeared in Indexer – Assigned – Descriptors (DEI) in INIS Database 1970-2002

Keyword	Frequency
gamma-radiation	4076
temperature-dependence	3220
experimental-data	2749
radiation-doses	2306
India	2000
cross-sections	1927
tracer-techniques	1855
magnetic-fields	1841
chemical-composition	1665
quantitative-chemical-analysis	1604
theoretical-data	1562
x-ray-diffraction	1547
mev-range-10-100	1532
solvent-extraction	1526
ph-value	1524
electric-conductivity	1480
chemical-preparation	1430
chemical-reaction-kinetics	1419
irradiation	1402
specifications	1398
infrared-spectra	1372
absorption-spectra	1350
comparative-evaluations	1331
stability	1296
cobalt-60	1255
spin	1247
transition-temperature	1202
wave-functions	1198
aqueous-solutions	1142
time-dependence	1135
ligands	1133
angular-distribution	1079
structural-chemical-analysis	1071
neutrons	1064
x-radiation	1061
physical-radiation-effects	1056
biological-radiation-effects	1022
dose-response-relationships	1017

Keyword	Frequency
Quantity-ratio	884
trace-amounts	876
sensitivity	868
mathematical-models	864
doped-materials	860
excitation	846
distribution-functions	841
superconductivity	840
dose-rates	827
energy-levels	824
phase-transformations	817
kev-range-100-1000	810
impurities	803
magnetic-susceptibility	803
Reviews	791
dispersion-relations	779
electronic-structure	779
energy-level-transitions	757
spectrophotometry	756
radiolysis	752
elastic-scattering	751
mass	750
electrons	741
Analytical-solution	739
medium-temperature	739
radiotherapy	716
nuclear-structure	705
alpha-particles	699
gamma-spectra	697
ground-states	691
barium-oxides	687
high-tc-superconductors	676
mev-range-100-1000	676
high-temperature	652
monocrystals	651
radiation-monitoring	649
photons	648
Magnetic-moments	641

Keyword	Frequency
differential-cross-sections	1008
energy-spectra	997
hamiltonians	979
mev-range-01-10	965
protons	949
uranium	949
annealing	940
copper-oxides	907
radiation-protection	902
labelled-compounds	885

Keyword	Frequency
chemical-radiation-effects	638
fabrication	638
excited-states	635
interfering-elements	633
oxygen	626
nitric-acid	618
Activation-energy	616
energy-dependence	607
Boundary-conditions	600
	truncated

CONCLUSION

This paper has highlighted quantitatively the contributions made by the Indian nuclear scientists during 1970 – 2002 as reflected in INIS database. During 33 years period (1970–2002) India has contributed significantly to the field of nuclear science and technology. A total of 55313 publications were published in the field of nuclear science and technology, which is 2.2% of the total world output. More than 50% of the publications were published in India and the rest were spread across other countries. The average number of publications per year by Indian scientists was 1676. The number of input of records per year by India to INIS database was 948.63. The collaboration trend among the Indian nuclear scientists is towards multi-author papers is indicative of the highly-specialised areas they were engaged in and look for more collaborative ventures locally and globally. There were as many as 163 papers with more than 20 authors each. About 14 papers had more than 100 authors each. There was one paper with 163 authors. During the period under study India had bilateral and multilateral international collaboration in the field. Bilateral international collaboration accounted for more than 80% of the collaborative papers. The publication behaviour indicates that the nuclear scientists were highly selective in publishing therefore results in highly specialized journals.

ACKNOWLEDGEMENTS

Authors are thankful to Mr. V. S. Dhakawal, Computer Division, BARC for his help and interaction while preparing this paper.

REFERENCES

Arunachalam, S. and Rino, S. I. 2001. Life sciences research in India: A profile based on BIOSIS 1998. *Information Today &Tomorrow*, Vol.2 no. 4:18 – 22.

Arunachalam, S. and Umrani, K. 2001. Mapping of agriculture research in India: A profile based on CAB abstracts 1998. *Information Today &Tomorrow*, Vol.20, no.4: 9-17.

Arunachalam, S. and Umrani, K.2001. Status of mathematics research in India in 1990 and 1994: An analysis based on MathSci. *Information Today &Tomorrow*, Vol.20, no. 4: 23- 30.

Balakrishnan, M.R. 1986. INIS: A computer-based international nuclear information system. *Information Services & Use*, Vol. 6: 51-73.

Begum, K. J. and Sami, L.K. 1986.Trends in Indian Agriculture research: An analytical study. *Annals of Library Science and Documentation*, Vol. 33: 163 – 172.

Department of Atomic Energy. 1988. *Forty years of Atomic Energy in India,* Department of Atomic Energy, Mumbai.

Department of Atomic Energy, 2004. *Atomic Energy in India: A perspective*, Department of Atomic Energy, Mumbai.

Garg, K. C. and Dutt, B. 1992. Bibliometrics of Indian science as reflected through Science Citation Index. *Journal of Scientific & Industrial Research,* Vol. 51: 329-340.

Gupta, B.M., Bose, P.R. and Rangarajan, K. S. 1980. Physics research in India – A birds eye view. *Physics News*, Vol.11, no.2: 1-8.

International Atomic Energy Agency, Presenting INIS.1987. IAEA, Vienna, Austria.

International Atomic Energy Agency, INIS progress and activity report 2002. 2003. IAEA, Vienna, Austria.

Kamath, V. A. 1976. Information systems in the field of nuclear science and technology, with special reference to Library and Information Services of BARC and its role in the development of atomic energy for peaceful purposes in India, *Annals of Library Science and Documentation*, Vol.23 : 24–44.

Karki, M. M. S.1990. Environmental science research in India: An analysis of publications. *Scientometrics*, Vol.18: 363 –373.

Verma, R.K.; Sharma, Y. K. and Khatri, H. S. D. 1982. Trends in nuclear research and its publications: An analysis based on five years coverage in the Indian Science Abstracts. *Annals of Library Science and Documentation,* Vol.29, no.2: 64-69.