Malaysian Journal of Library & Information Science, Vol.7, no.1, July 2002: 17-30

SCIENTOMETRIC DIMENSIONS OF TECHNICAL REPORTS FROM BHABHA ATOMIC RESEARCH CENTRE

T. Swarna, V.L. Kalyane and **Vijai Kumar**
Library and Information Services Division,
Bhabha Atomic Research Centre,
Trombay, Mumbai-400 085, India.
e-mail: swarnamurthy@hotmail.com
vkalyane@yahoo.com

ABSTRACT

Technical report is one of the media to record the scientific information generated by scientists and engineers. Bhabha Atomic Research Centre (BARC) published 554 technical reports during 1990-99 under the categories: External (373) and Internal (181). Engineering and technology generated 207 technical reports followed by chemistry, materials and earth sciences (129), while their interdisciplinary interactions resulted in 31 technical reports. Life and environmental sciences produced 42 technical reports; followed by Physics (16); Other aspects of nuclear and non-nuclear energy (6); Isotopes, isotope and radiation applications (4). Technical reports in subjects outside the scope of nuclear science and technology were 69. Scientometric analysis of these reports has been carried out for physical bibliographic characteristics, authorship collaboration, inter-divisional collaboration, inter-institutional collaboration activities and content analysis. Types of documents referenced in the technical reports indicated first rank for journal articles, followed by books, technical reports, conference papers, standards/codes, personal communications, patents, theses, drawings, and lectures.

Keywords: Technical report; Collaboration coefficient; Information generation and dissemination; Single research institute productivity; Conventional sources; Non-conventional sources; Bhabha Atomic Research Centre; Scientometrics; Bibliometrics.

INTRODUCTION

Conventional sources such as books, journals, standards, and patents as well as non-conventional sources like conference proceedings, preprints, translations, theses, dissertations, and technical reports, form major channels of research and development communications. The largest element of non-conventional literature is the technical reports (Dossett, 1992). Perhaps, the origin of technical reports as a channel of confidential and faster means of communication may be traced to the censorship of publications in journals (Atkins, 2000).

Technical reports are accepted bibliographic format for the dissemination of technical data and information generated through R&D efforts in specific field(s)

is the accepted channel for scientific research. The probability of research results being first published in the form of a technical report is very high as compared to other forms of literature like patent, thesis, and journal article. Hence, technical reports can be considered as an important vehicle of fast flow of communication in science and technology. Technical reports embrace a wide spectrum of information in all branches of science, engineering, technology, social and behavioural sciences, inter-disciplinary areas including various aspects of energy and environment, and even some branches of humanities. Phenomenal increase in scientific and technical research has led to the exponential growth in the publication of technical reports. Desktop publishing has further accelerated the growth of technical reports (Kalyane, 1992).

Technical reports perform one or few of the following functions: to inform the readers/users, to initiate action which forms a basis for arriving at a decision, to record for archival or future use, to maintain the history of a job, and to facilitate administrative or legal requirements.

Debates recurring on technical reports include: the uneven quality of technical reports, which may be due to the fact that most of the authors are scientists, engineers or technologists who may not have been well trained in the skills of technical writing; urgency of reporting under pressure of time; not refereed by external experts due to their confidential nature; and limitations of editorial facilities. The contents of the technical reports are diverse and of formal nature when compared with journal articles.

This paper presents the study of some features in technical reports published by the Bhabha Atomic Research Centre (BARC). BARC is one of India's centres for multi-disciplinary R&D work in nuclear science and technology (DAE, 2000; Kakodkar, 2000). The various research activities result in generating a large amount of publications in the form of journal articles, conference presentations, books, manuals and technical reports.

The importance of technical reports in R&D environment is becoming increasingly recognised. For many organisations they encapsulates vital know-how representing the cutting edge (Jeffery, 2000). Recent focus has been on analysis of publications emanating from a single R & D Institute (Kalyane and Kalyane, 1991; Kalyane and Kalyane 1994; Kalyane and Kalyane, 1996; Kalyane and Rao, 1992). However, the authors have not noticed literature on technical reports encompassing single R & D Institute. Studies had focused on user's survey of lent out technical reports (Sridhar, 1984); shelf arrangement of technical reports (Bhat and Raju, 1980); and the citation rank of the technical reports compared to the periodicals in astronautics and aeronautics (Bhat and Raju, 1977).

SCOPE

The present study on technical reports of BARC has been undertaken in order to satisfy the following objectives: to record annual quantitative output data, to compare cumulative flow over a period of ten years, and to calculate collaboration coefficients. An attempt is made to know the output of single divisional versus multi-divisional origin and also the output in collaboration with other R&D institutes. This study also provides subject and content analysis of the disciplinary and inter-disciplinary outputs. Sources cited in technical reports have been categorised into conventional and non-conventional sources.

Commonly a report bears a number that identifies both the report and the issuing organisation. The nomenclature being used for BARC technical reports is: BARC / year of publication / type of report (external or internal)/ serial number in that year and in that particular type of category. All BARC technical reports follow a standard format as specified in IS: 9400-1980 (ISI, 1980).

The cost of production and dissemination is borne by the source corporate R&D institution itself, and sometimes it gets extremely expensive (Scammell, 1997). However, the end user receives the technical reports free of charge, in time, and at the exact location of work. The service is designed to meet a substantial element of the information needs of specially targeted groups.

Table 1 indicates the number of technical reports published by BARC during the period 1990 to 1999. The sample of this study comprises 554 reports, that is 373 external and 181 internal.

Table Number of Technical Reports Produced by BARC during 1990-1999

Year	External	Internal	Total	Cumulative
1990	42	30	72	72
1991	37	22	59	131
1992	48	12	60	191
1993	36	25	61	252
1994	45	15	60	312
1995	21	22	43	355
1996	31	11	42	397
1997	35	15	50	447
1998	35	18	53	500
1999	43	11	54	554
		181		

External = Distribution within and outside India
Internal = Distribution within the Units of the Department of Atomic Energy of India

METHODS

Statistical analysis of the physical bibliographical characteristics of the 554 BARC technical reports published from 1990 to 1999, for pages, figures, tables, illustrations, annexure plus appendices, photographs, and graphs, were considered for measures of central tendencies.

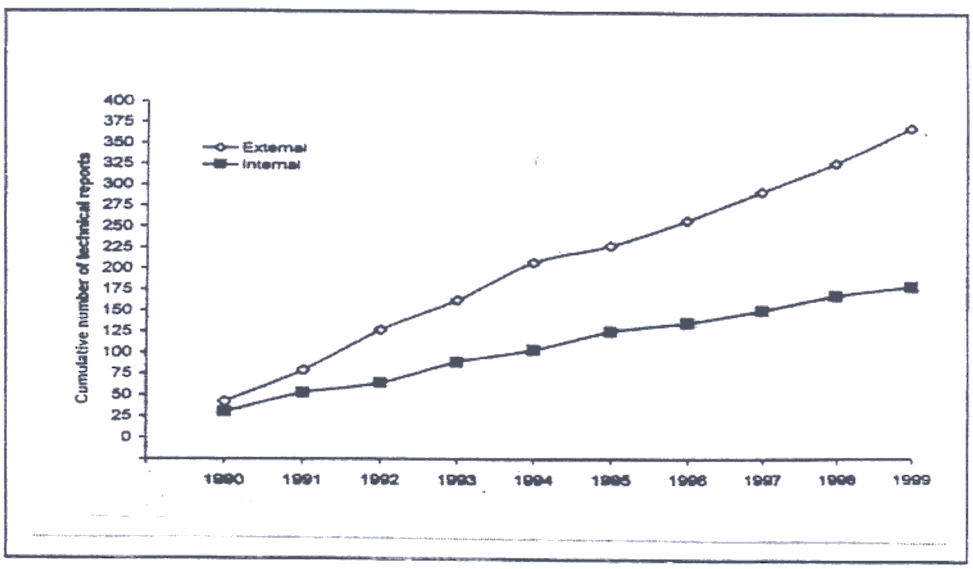
All the authors of 554 technical reports have been considered to study the degree of collaboration between the researchers. Collaboration coefficient is the ratio of the number of collaborative papers to the total number of single plus multi-authored papers (Subramanyam, 1983). This formula has also been applied to study the collaboration coefficient within BARC as well as with other institutes. For this study, the authors' affiliations have been taken into consideration. Corporate anonymous technical reports from BARC were taken as multi-authored publications (as these are expected to be the output of many individuals) for calculation of the collaboration coefficient.

For papers in the various fields, all subject categories assigned to the reports have been included in the study. A total of randomly selected one hundred technical reports were categorised for ranking, by type of source documents.

RESULTS AND DISCUSSION

Figure 1 indicates the yearly cumulative growth of the various categories of technical reports published during 1990 to 1999. The highest growth rate was observed for External reports, followed by Internal reports. On an average there is a flow of about 6 to 7 reports per month from BARC.

Figure 1 Year wise cumulative growth of BARC technical reports (1990-1999)



(a) Physical Bibliographic Characteristics

The structure of technical reports can be visualised from the physical bibliographic characteristics. The study of central tendencies (Parker, 1984) include: the pages per report ranged from 7 to 720; average number of pages per report was 49; forty-nine reports of 21 pages each occurred most frequently (mode), and the median for the distribution of number of pages per report was 34. The number of figures ranged from 0 to 460, with a mean of 11. The number of tables ranged from 0 to 160, with mean being 8. Illustrations ranged from 0 to 12, with a mean of 3. Annexure plus appendices ranged from 0 to 7, with a mean of 3. Photographs ranged from 0 to 64, the mean being 3 and graphs ranged from 0 to 111, with a mean of 23.

(b) Authorship Collaboration

Table 2 indicates authorship collaboration of the technical reports. The collaboration coefficient is appreciably high, ranging from 0.81 to 0.96.

Table 2: Single Authored and Multi-Authored Technical Reports Published during 1990 - 1999 with Annual Collaboration Coefficients (CC)

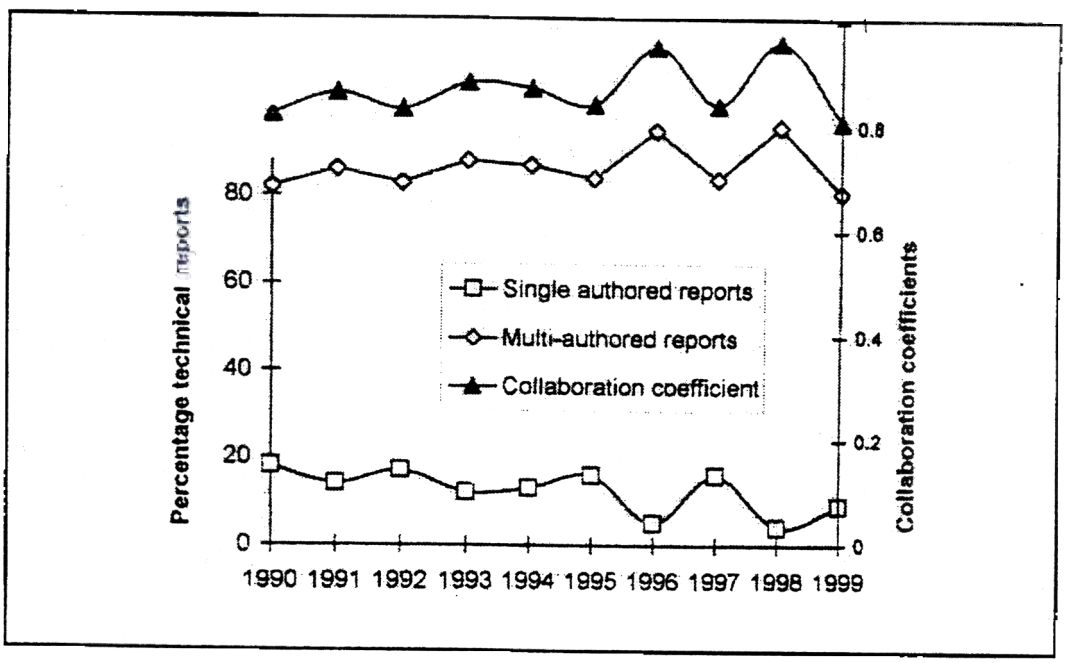
Year	Single Authored S	Multi-Authored M	Total S + M	CC M / (S +M)
1990	13	59	72	0.82
1991	8	51	59	0.86
1992	10	50	60	0.83
1993	7	54	61	0.88
1994	8	52	60	0.87
1995	7	36	43	0.84
1996	2	40	42	0.95
1997	8	42	50	0.84
1998	2	51	53	0.96
1999	10	44	54	0.81
Total	75	479	554	0.86

Table 3 shows authorship pattern in 554 technical reports published during 1990 to 1999 and indicates that 126 had three authors, 98 were four authored, 83 reports were two authored, and 65 reports were five authored. Two reports had fourteen authors each. The collaboration activity has been appreciably high in 1996 and 1998 (Figure 2).

Table 3: Authorship Pattern in BARC Technical Reports (1990 – 1999)

No.of Author/s N	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total Report T	Total Author ship N x T
Single	13	8	10	7	8	7	2	8	2	10	75	75
Two	10	11	5	14	8	5	6	10	8	6	83	166
Three	10	15	15	12	14	9	9	14	16	12	126	378
Four	9	9	9	9	13	7	11	11	10	10	98	392
Five	11	7	9	5	5	6	7	2	7	6	65	325
Six	5	1	4	5	8	2	2	1	3	5	36	216
Seven	5	4	4	4	0	0	2	3	1	1	24	168
Eight	0	0	0	1	1	2	2	0	3	1	10	80
Nine	0	1	0	2	0	0	0	0	2	1	6	54
Ten	0	1	2	0	0	1	1	0	0	0	5	50
Eleven	0	0	0	0	0	0	0	0	0	1	1	11
Twelve	1	0	0	0	1	0	0	0	0	0	2	24
Thirteen	0	0	2	1	0	0	0	1	0	0	4	52
Fourteen	1	0	0	0	1	0	0	0	0	0	2	28
Corporate	7	2	0	1	1	4	0	0	1	1	17	17
Total	72	59	60	61	60	43	42	50	53	54	554	2036

Figure 2: Yearly Percentage of Single Authored and Multi Authored BARC Technical Reports (1990-1999) and their Collaboration Coefficients



(c) Inter-Divisional Collaboration

Table 4 indicates research collaboration within the various divisions and with other institutions. The collaboration coefficient between various divisions ranged from 0.11 to 0.31.

Table 4: Research Collaboration Within BARC and Other Institutes by the Technical Reports Published During 1990 -1999

Year	Single Division	Multi-Division	Total	Collaboration coefficient(Div.)	BARC & other Institutes	Collaboration coefficient
	a	b	a + b	b / (a + b)	c	c / (a +b+c)
1990	62	8	70	0.11	2	0.03
1991	48	8	56	0.14	3	0.05
1992	44	16	60	0.27	0	0.00
1993	44	14	58	0.24	3	0.05
1994	40	18	58	0.31	2	0.03
1995	31	8	39	0.20	4	0.09
1996	28	11	39	0.28	3	0.07
1997	38	5	43	0.12	7	0.14
1998	38	11	49	0.22	4	0.08
1999	37	13	60	0.26	4	0.07
Total	410	112	532	0.22	32	0.06

(d) Inter-Institutional Collaboration

BARC has established collaboration activities with other institutes in India. However, the collaboration coefficient between BARC and other institutes have remained low which may be because of its super-specialised research character.

Collaboration, both within the Divisions of BARC and with other institutes is an indication of the inter-disciplinary and multi-disciplinary approach being earnestly followed in the pursuit of excellence. Besides, in the competitive world of today, research is both expensive and time bound, more so in the field of nuclear science and technology. Hence, sharing of resources, which include financial, human resource, equipment, facilities, technical know-how, etc. is essential. BARC encourages individual as well as collaborative research.

(e) Content Analysis

Table 5 gives the subject categorisation of the technical reports and indicates interdisciplinary and multi-disciplinary nature of research. All the reports are assigned subject categories according to the International Nuclear Information

System (INIS) subject categories (BSI, 1993) as indicated in Table 5. Those publications that did not fall in the scope of nuclear science and technology have been classified according to the Universal Decimal Classification scheme (IAEA, 1997).

Content analysis of the reports was also conducted, and if more than one discipline was dealt with, then those disciplines were also mentioned. Contents of the technical reports stem from organisational objectives and functions and are meant to support their executive functions and performance. Research efforts are geared to achieve targets in scientific, industrial and economic growth, technological innovations, with an orientation towards social goals. These efforts are related to the country's development planning and growth targets.

Table 5: Disciplinary and Interdisciplinary Contents of BARC Technical Reports (1990-1999)

	Secondary Subject								
Main Subject	**B**	**C**	**D**	**E**	**F**	**G**	**Nn**	Total	%
B	**129**	2	4	10	1	5		151	27.3
C	5	**42**	1	2				50	9.0
D	1		**4**	1				6	1.1
E	21	3	4	**207**	3	2		240	43.3
F	4			7	**6**			17	3.0
G	2			3		**16**		21	3.8
Nn							**69**	69	12.5
Total	162	47	13	230	10	23	69	554	100.0

Columns: Main subject category; and rows : Secondary subject category; INIS Domains **B**: Chemistry, Materials and Earth Sciences; **C**: Life and Environmental Sciences; **D**: Isotopes, Isotope & Radiation Applications; **E**: Engineering & Technology; **F**: Other Aspects of Nuclear and Non-nuclear Energy; **G**: Physics; and **Nn**: reports not in the scope of INIS nuclear science and technology; Tuple: bold for disciplinary, normal for interdisciplinary, and blank cells for nil interdisciplinary report.

The highest number of technical reports is in Engineering and Technology (240), followed by Chemistry, Materials and Earth Sciences (151) with about 43 and 27 percentages respectively. This is expected because BARC is committed to the

development of reactor technology, which forms the core of its R & D programme. The results indicate that the research results in the field of engineering are lesser amenable for publication in journals and hence, most of the research results are published in the form of technical reports.

Frequencies of technical reports in various disciplines are provided in Table 6. There were a total of 473 technical reports belonging to single disciplines. These were further analysed to ascertain annual productivity.

Table 6: Frequency of BARC's Disciplinary Technical Reports -1990-1999

Year	INIS Subject Categories							Total
	B	**C**	**D**	**E**	**F**	**G**	**Nn**	
1990	21	5	1	15	1	2	8	53
1991	25	6	1	20	3	1	5	61
1992	13	0	0	31	1	2	3	50
1993	15	2	0	23	0	3	4	47
1994	12	4	0	21	1	1	7	46
1995	6	8	1	17	0	2	3	37
1996	6	2	0	16	0	0	12	36
1997	7	4	0	24	0	1	13	49
1998	15	7	1	20	0	1	7	51
1999	9	4	0	20	0	3	7	43
Total	129	42	4	207	6	16	69	473

Disciplinary i.e. INIS single subject category **B**: Chemistry, Materials and Earth Sciences; **C**: Life and Environmental Sciences; **D**: Isotopes, Isotope & Radiation Applications; **E**:Engineering & Technology; **F**: Other Aspects of Nuclear and Non-nuclear Energy; **G**: Physics; and **Nn**: reports not in the scope of INIS nuclear science & technology

Figure 3 indicates the annual cumulative growth of various disciplinary subject categories only of the technical reports published during 1990 to 1999. The highest growth rate was observed in Engineering and Technology, followed by Chemistry, Materials and Earth Sciences, and Non-nuclear subjects. The results indicated that in Engineering and Technology, an average of 20 reports per year were published during the period from 1990 to 1999 followed by 7 reports in Non-nuclear subjects. In Other Aspects of Nuclear and Non-nuclear Energy, and Isotopes, Isotope and Radiation Applications only 6 and 4 reports had been published respectively.

Figure 3: Cumulative Growth BARC's Technical Reports by Domain:1990-1999

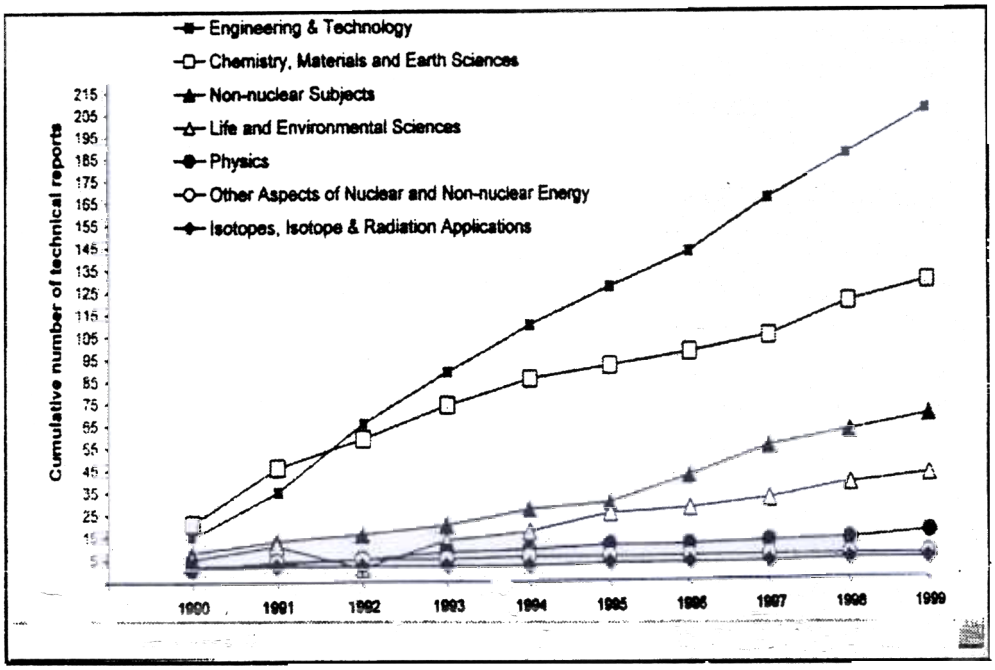


Table 5 also indicates the emergence of interdisciplinary interactions as reflected in the context of the origin of the Division to which the authors belong. The Interdisciplinary collaboration between Engineering and Technology (E) with Chemistry, Materials and Earth Sciences (B) was highest, with 21 technical reports, followed by Chemistry, Materials and Earth Sciences (B); and Engineering & Technology (E) with 10 reports. Thus, these two disciplines have a total of 31 interdisciplinary technical reports. Ten reports were produced between Other Aspects of Nuclear and Non-nuclear Energy (F) and Engineering & Technology (E) categories. Seven interdisciplinary technical reports were between Chemistry, Materials and Earth Science (B); and Physics (G). Life and Environmental Sciences (C); and Chemistry, Materials and Earth Sciences (B). The blank cells indicate that no technical report has been published till 1999 between respective domains and there is scope for such research in future.

(f) Categorisation of References

References play a very important role in scientific literature. They not only vouch for the authority and relevance of the statements that are called upon to support but they also embed the work reported in context of previous research. A paper that contains no references to previous research may be an indication

that the research is a new contribution or review of literature has not been done. References also contribute to the intricacy of a paper. The cited papers must be read for a full comprehension.

Table 7 indicates the categorisation and ranking of 3086 references appended to 100 technical reports (random sampling).

Table 7: Categories and Ranks of the References Cited in 100 BARC Technical Reports Published During 1990-1999

Types of sources cited		%	Rank
Conventional sources			
Published	Journal articles	74.82	I
	Books	9.47	II
	Standards/Codes	1.26	V
	Patents	0.49	VII
Non-conventional sources			
Published	Technical reports	7.60	III
	Conference papers	4.80	IV
Unpublished	Personal communications	0.91	VI
	Theses	0.36	VIII
	Drawings	0.26	IX
	Lectures	0.03	X

It is observed that all types of sources, conventional as well as non-conventional, were consulted by the researchers. About 85% of references were conventional sources like journal articles, books, standards/codes, manuals and patents; and about 15% were non-conventional sources like technical reports, conference papers, theses, personal communications, drawings and lectures. The term 'self-citations' describes the relationship between the citing technical report and cited technical report. About 36% of the total technical reports cited were self-citations i.e. belonging to BARC whereas 64% of the report literature cited was of other organisations.

This finding is supported by Kent, Lancour, Daily and Nasri (1968). Documents consulted by the scientists surveyed are almost entirely made up of conventional literature such as books, and journal articles, but those used by engineers are about equally divided between conventional and non-conventional literature.

Conference literature forms a vital communication link in many fields of science and engineering. Quite often the first public disclosure of important science and

technology development or discoveries is presented at conferences, symposia or meetings having similar designations. Conference material constitutes a significant portion of the scientific literature, and frequently contains information not available elsewhere, or early results presented ahead of more formal scientific publications. A great quantum of information is communicated by personal contact between researchers with similar interests brought together at conferences, which may or may not be recorded in print but influences future course of research planning endeavour.

Another noteworthy feature is the interpersonal communication as an information transfer channel. Informal interpersonal communication is probably the most essential channel of information transfer for majority of scientists and engineers. This type of communication may be through correspondence or discussions. Recently, email has facilitated easier and quicker means of such communication.

CONCLUSIONS

Technical reports have their own distinct role to play in the communication of scientific and technical information. A proper understanding of the unique features will lead to their more effective utilisation. Authors, editors, publishers, librarians, scientists and engineers, and science policy makers, could well benefit from in-depth study of the technical reports as a communication medium.

Contents and references analysis in technical reports might highlight context wise citer motivation and information seeking behaviour. This may facilitate selective dissemination of information and acquisition programme of sources, in order to satisfy the information needs by understanding information-referring behaviour and thereby projecting the information seeking behaviour of the researchers with empathy (Kalyane and Devarai, 1994).

REFERENCES

Atkins, S. E. 2000. *Historical Encyclopedia of Atomic Energy.* London Greenwood Press. pp 258-260.

, V. G. and R.E. Raju. 1977. Ranking of periodicals in the field of astronautics and aeronautics. *Annals of Library Science and Documentation*, Vol. 24 no. 3-4: 114-118.

V. G. and R.E. Raju. 1980. Organisation of report literature in a technical library having moderate collections: a case study. *Annals of Library Science and Documentation*, Vol. 27 no. 1-4: 30-33.

BSI 1993. *Universal Decimal Classification*, International Medium Edition, BS 1000M. London : British Standard Institute

DAE 2000. *Department of Atomic Energy: Annual Report 1999-2000*, Department of Atomic Energy: 2.1.

Dossett, Patti (ed), 1992. *Handbook of Special Librarianship and Information Work*, 6th ed. London, Aslib. p 123.

IAEA 1997. *INIS: Subject Categories and Scope Descriptions*. Rev.8. Vienna : International Atomic Energy Agency. pp 13-131.

ISI 1980. *Indian Standard: Guide for the preparation of Bibliographic Description sheet for Technical Reports*. New Delhi: Indian Standards Institution New Delhi. pp 1-9.

Jeffery, Keith G. 2000. An architecture for grey literature in an R&D context *Journal of Grey Literature*. Vol. 01, no. 2: 64 -72.

Kakodkar, Anil 2000. Foreword, *BARC Progress Report – 1999*. Mumbai : Library & Information Services Division, Bhabha Atomic Research Centre. p iii.

Kalyane, V. L. and R.S. Devarai. 1994. Empathy in public librarianship: a subjective and qualitative analysis, *Indian Journal of Information Library and Society*, Vol. 7 no. 1-2: 87-104.

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

Kalyane, V. L. and S.V. Kalyane. 1992. Librarianship in 2000 AD, *University News*, Vol. 30 no. 35: 73-74.

Kalyane, V. L. and S.V. Kalyane. 1994. R&D communication strategy *vis-à-vis* librarianship, *Journal of Information Sciences*, Vol. 4 no. 3: 105-135.

Kalyane, V. L. and S.V. Kalyane. 1996. 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, V. L. and Vidyasagar Rao. 1992. Collaboration trends in sugarcane research: a case study. *Annals of Library Science and Documentation*. Vol. 39 no. 1: 9-11.

Kemp, D. Alasdair 1988. *Computer-based Knowledge Retrieval*. London : Aslib. p 139.

Kent, Allen; Harold Lancour; Jay E. Daily and William Z. Nasri. (Eds) 1968. *Encyclopedia of Library and Information Science*: *Vol. 30*. New York : Marcel Dekker. p 146.

Parker, Sybil P. (Ed) 1984. *McGraw-Hill Dictionary of Scientific and Technical Terms*. 3rd ed. New York : McGraw-Hill Company. pp 985, 989, 1032.

Scammell, Alison (ed) 1997. *Handbook of Special Librarianship and Information Work* 7th ed. London : Aslib. p 98.

Sridhar, M. S. 1984. Use of technical reports and standards. *IASLIC Bulletin*, Vol. 29 no. 3 : 99-106.

Subramanyam, K. 1983. Bibliometric studies of research collaboration: review. *Journal of Information Science*, Vol. 6 no. 1 : 33-38.

Watters, Carolyn 1992. *Dictionary of Information Science and Technology*. London : Academic. pp 234-235.