

A QUANTITATIVE STUDY OF INDIAN ENGINEERING LITERATURE

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In recent years, several projects were sponsored by NISSAT of the Government of India to map Indian Science. As a part of it, a database (COMPENDEX) in engineering field was analysed. It has been found that engineers in India publish their articles mostly in journals; almost all of them publish in English language. They publish in a selected few journals. Only a few of the institutions are concentrated in engineering research. It has been observed that research output in applied physics, light & optics, bioengineering and information science are increasing both at the world and India level. In the area of energy technology metallurgical engineering and food technology, research output is decreasing at both levels.

Introduction

An important area of informetrics research is "application of quantitative techniques" to "science in general and science communication (science output, science policy, science administration, etc.) in particular" with objectives to develop science indicators, to measure the impact of science, and to compare the output at national and international levels. Some of the science indicators are:

- i) number of papers published by individuals and also by institutions;
- ii) number of papers per author, number of authors per paper, etc.;
- iii) α in Lotka's laws – the higher the α , the less the number of most productive scientists;
- iv) growth and obsolescence rates;
- v) impact factor, activity index, collaboration index, immediacy index, etc.;
- vi) manpower statistics: male and females, qualified scientists at different levels, etc.;
- vii) R & D expenditure;
- viii) awards received – at the national and international levels, number of scientists in various editorial boards of learned periodicals, etc.

A number of papers in this area have been published in India. Detailed bibliographical references are given in another publication (*Ravichandra Rao, 1997*). In recent months, the National Information Systems for Science & Technology (NISSAT) of the Government of India has undertaken a series of projects to map the scientific work done in India. As a part of these projects, many international bibliographical databases were analysed. For example, the following analyses of literature were carried out:

- i) on agricultural research in India, based on the 9366 papers covered in *CAB Abstracts* (1992) (*Arunachalam, 1997*);
- ii) on physics research in India, based on the INSPEC database (*Dhavan and Arunachalam, 1998*);
- iii) based on SCI (*Basu and Nagpaul, 1998*);
- iv) on earth science research in India, based on the data from *GeoRef* database (*Sahu et al., 1998*);
- v) on biomedical sciences, based on the coverage in *Index Medicus, Excerpta Medica and Tropical Disease Bulletin* (*Satyanarayana, 1998*).

The detailed results are given in their respective reports. Bibliographical references mentioned in section 6 refer to the works done in India, which are related to the theme of the paper. Similar works have of course been done in other parts of the world and they are not cited in this paper.

The objective of this paper is to present the findings of the analyses of the Indian engineering literature covered in COMPENDEX for two years.

Analyses of COMPENDEX Plus

NISSAT sponsored a project on "National Mapping of Science". As a part of this project, analyses of an engineering database with the following objectives were carried out:

- to find India's share in the world of engineering literature;
- to identify the journals used by the Indian engineers;
- to identify the core institutions involved in engineering research;
- to identify the kind of documents that are published.

Table 1
Trends in the growth of literature in certain branches of engineering

Growth Trend	Branches of Engineering
Both increasing – World literature increasing Indian literature increasing	Applied Physics – (High Energy, Plasma Nuclear & Solid State) Light and Optics, Bioengineering, Information Science.
Both decreasing – World literature decreasing Indian literature decreasing	Energy Technology & Petroleum Engineering Mining, Metallurgical Engineering and Material Science Food Technology
World's literature is increasing whereas India's contributions decreasing	Electronics, Computers and Communication Electrical, Instrumentation, Control Engineering & Power Engineering Environmental Technology Marine Engineering, Naval Architecture, Ocean and Underwater Technology Aeronautical and Aerospace Engineering
World's literature decreasing whereas India's contributions increasing	Chemical Engineering, Ceramics, Plastics and Polymers Engineering Management and Industrial Engineering Civil and Structural Engineering Mechanical Engineering, Automotive Engineering & Transportation

For the purpose of this study, COMPENDEX databases for the years 1990 and 1994 were analysed. After removing duplicate records, pertaining to India, we have observed that there were 3520 and 4829 bibliographical records for the years 1990 and 1994, respectively. Indian engineers published their output in a variety of documents: journals, conference proceedings, monographs and reports; 88% of the output was published in journals and 11.5% of the output was published in conference proceedings; monographs and reports constituted only 0.5%. Like in other fields, also engineers use journals as most important media for communicating their research work. In order to facilitate the comparison between the world and Indian contributions to the engineering literature in 1990 and 1994, percentage shifts (shifts in respect to the number of publications in different branches of engineering) from 1990 to 1994 were computed; also an activity index was computed. These are given in Table 2.

Table 2
World and Indian contributions to engineering literature as seen from COMPENDEX Plus bibliographic database in 1990 and 1994
(arranged alphabetically according to subject alphabetical)

Branches	World				India				Activity Index				
	No. of papers 1990	No. of papers 1994	Percentages 1990	Percentages 1994	No. of papers 1990	No. of papers 1994	Percentages 1990	Percentages 1994	Total	Shift	1990	1994	Shift
Aerospace	169	261	0.09	0.09	153	101	4.35	2.09	3.04	+2.26	49.500	24.909	+24.591
Applied physics	24106	53669	12.52	17.27	235	798	6.67	16.53	12.37	-9.86	0.533	0.957	-0.424
Bioengineering	1294	2402	0.67	0.77	118	204	3.35	4.22	3.86	-0.87	4.986	5.467	-0.481
Chemical engineering	53968	32620	28.04	10.49	725	1047	20.59	21.68	20.62	-1.09	0.735	2.066	-1.331
Civil engineering	6946	10807	3.61	3.48	189	272	5.37	5.63	5.52	-0.26	1.488	1.620	-0.132
Electrical	22695	53082	11.79	17.08	361	310	10.25	6.42	8.05	+3.83	0.869	0.376	+0.493
Electronics	19067	44821	9.91	14.42	380	350	10.79	7.25	8.74	+3.54	1.089	0.503	+0.586
Energy technology	10213	9159	5.31	2.95	244	198	6.93	4.10	5.29	+2.83	1.306	1.392	-0.086
Industrial engineering	14117	11775	7.33	3.79	90	283	2.55	5.86	4.46	-3.31	0.348	1.547	-1.199
Environmental technology	1539	3573	0.80	1.15	235	99	6.68	2.05	4.00	+4.63	8.349	1.783	+6.566
Food technology	958	658	0.50	0.21	26	31	0.73	0.64	0.68	+0.09	1.484	3.035	-1.551
Information science	820	11464	0.43	3.69	5	30	0.14	0.61	0.44	-0.47	0.333	0.168	+0.165
Light and optical technology	25837	58176	12.38	18.71	137	242	3.89	5.01	4.54	-1.12	0.314	0.268	+0.046
Machine engineering	2293	4021	1.19	1.29	125	161	3.55	3.33	3.42	+0.22	2.980	26577	+0.403
Mechanical engineering	8745	13272	4.54	4.27	122	224	3.47	4.64	4.12	-1.17	0.769	1.086	-0.317
Mining etc.	1709	1083	0.89	0.35	433	421	12.30	8.72	10.23	-3.58	13.854	25.023	-11.169
Total	192476	310843			3520	4829							

The activity index (AI) is computed as

$$AI = \left(\frac{f_i}{\sum_{i=1}^n f_i} \right) \left(\frac{\sum_{i=1}^n F_i}{F_i} \right) \times 100$$

where f_i and F_i refer to India's and World's data in different branches of engineering, respectively. The "shifts" may be classified into four major groups as follows:

- World and Indian contributions in particular branches are increasing;
- World and Indian contributions in particular branches are decreasing;
- World's contributions are increasing whereas Indian contributions are decreasing;
- India's contributions are increasing whereas World's contributions are decreasing.

Subject-wise analyses in different periods of time give rise to lots of information. Such analyses will help us to see the changes in the interest of research, importance of certain subjects, etc. Based on the classification scheme adopted in the COMPENDEX Plus, the records were grouped, to arrive at a subject-wise distribution of papers. The data were presented in Table 2. Table 1 gives the trends in growth of literature in certain branches of engineering.

It may be observed that the research output in applied physics, light & optics, bioengineering and information science are increasing both at the world and India level. However, the rate at which it is increasing varies from each other. In applied physics, India's output is increasing at a lower rate than world's output whereas, in optics & information science and its related area, India's contributions are increasing much faster than the world's contribution. The rate at which the literature in the area of bioengineering increased is almost the same at both levels. In the area of energy technology, metallurgical engineering and food technology research, output is decreasing at both levels. In the branches of electrical engineering & electronics, computers & communications, environmental technology, marine engineering and aeronautical engineering, the world research outputs are increasing, whereas India's output is decreasing from 1990 to 1994. In environmental technology, India's research output is decreasing at the rate of approximately 4%. However in the remaining branches, that is, civil engineering, industrial engineering and, mechanical engineering, the world's publications are decreasing, where as India's contributions are increasing from 1990 to 1994. In industrial engineering the rate at which the world output is decreasing is almost the same as that of India.

Document type and language analysis

Among the research publications, the type of documents has a specific role to play in dissemination of information. The form of the document reveals the nature, scholarlyness and currency of the information. Table 3 gives the data on the type of documents, used as a vehicle for communication, by the Indian engineers. Almost all publications are in English – 3510 and 4814 documents were published in English in 1990 and 1994, respectively. Seven and two articles were published in German in 1990 and 1994, respectively. In 1994, there were six articles in Russian and one in French.

Table 3
Indian papers classified according to document type
(as seen from the COMPENDEX database in 1990 and 1994)

Rank	Document type	No. of papers			%		
		1990	1994	Total	1990	1994	Total
1.	Journal articles	3089	4263	7352	87.76	88.27	88.06
2.	Conference articles	429	538	967	12.19	11.14	11.58
3.	Monograph chapter	1	20	21	00.25	00.41	00.25
4.	Reports	1	1	2	00.25	00.02	00.01
5.	No. of records without any code for type of document	0	8	8	00.00	00.16	00.10
Total		3520	4830	8350	100.00	100.00	100.00

Treatment-wise analysis

It may be noticed from the 1990 and 1994 data (from Table 2) that Indian engineers contributed the most (20.62%) in the field of chemical engineering and related topics. The other branches of engineering to which India is contributing are applied physics (12.37%), metallurgical engineering and related subjects (10.32%) and electronics & related subjects (8.74%). Further, we have noticed that experimental research, applied research, theoretical and general review constituted about 46.96%, 23.36%, 15.79% and 10.99%, respectively. Details are given in Table 4.

Institution-wise analyses

The individual institutions contributing to the field as seen from the COMPENDEX in 1990 and 94 are classified into 4 major groups – Academic, Laboratories, Government (central and state) and Industries. These groups are further classified into

subgroups. The "academics" are classified as universities, institutions of national importance, engineering colleges, agricultural institutions, medical institutions and other academic institutions. The "laboratories" are again classified as Council of Scientific and Industrial Research (CSIR) and Defence Research & Development Organisation (DRDO) labs. The "industries" are classified as private and public. The "central government institutions" are classified further into different departments. It is observed from the 1990 and 1994 data that the academic institutions contribute 60% of the publications; labs, government institutions and industries contribute 16%, 15.3% and 7%, respectively. Among the academic institutions, premier institutions such as Indian Institute of Science, Indian Institutes of Technology, Regional Engineering Colleges, Indian Institutes of Management, Indian Statistical Institutes, contributed 40% of publication. Contributions made by different organisations are summarized in Table 6. Table 5 gives the distribution of Institutions over the papers. Like many other distributions, the distribution of institutions indicate that there are very few institutions contributing quite a lot and most of the institutions are contributing much less!

Table 4
Indian papers classified according to treatment as seen from the COMPENDEX database in 1990 and 1994
(arranged according to total number of papers)

Rank	Treatment	1990 No. of papers	1994 No. of papers	Total No. of papers
1	Experimental	1781 (50.6%)	2140 (44.36%)	3921 (46.96%)
2	Applications	753 (21.39%)	1198 (24.80%)	1951 (23.36%)
3	Theoretical	585 (16.62%)	734 (15.2%)	1319 (15.79%)
4	General review	238 (6.67%)	680 (14.08%)	918 (10.99%)
5	Economic (cost data) market	109 (3.09%)	29 (0.60%)	138 (1.65%)
6	Literature review/bibliography	17 (0.48%)	13 (0.27%)	30 (0.36%)
7	Management aspects	8 (0.23%)	17 (0.35%)	25 (0.3%)
8	Numerical	18 (0.51%)	7 (0.14%)	25 (0.3%)
9	Historical	3 (0.08%)	0 (0.00%)	3 (0.03%)
10	No. of records without any treatment code	8 (0.23%)	11 (0.23%)	19 (0.23%)
		3520 (100.00)	4829 (100.00)	8349 (100.00)

Table 5
The distribution of institutions by the number of papers

No. of papers	1	2	3-10	11-50	51-100	>100
No. of institutions	527	151	204	84	16	13

Table 6
Contributions made by different organisations as seen from COMPENDEX database in 1990 and 1994

	No. of publications			Percentages		
	1990	1994	Total	1990	1994	Total
Academic						
Universities	811	1217	2028	39.25	41.45	40.54
Institutions of national importance						
IIT	691	936	1627	33.45	31.88	32.53
I.I.Sc.	191	299	490	9.24	10.18	9.79
R.F.C.	37	59	96	1.79	2.00	1.92
I.S.I.	15	37	52	0.72	1.26	1.04
I.I.M.	11	10	21	0.53	0.34	0.42
Other engineering colleges	108	126	234	5.22	4.29	4.68
Institutions related to						
Agriculture	109	76	185	5.27	2.59	3.69
Medicine	25	23	48	1.27	0.78	0.95
Others	68	153	221	3.29	5.21	4.49
Total	2066	2936	5002	100.00	100.00	100.00
Labs						
C.S.I.R.	508	632	1140	84.80	85.40	85.14
D.R.D.O.	91	108	199	15.19	14.59	14.86
Total	599	740	1339	100.00	100.00	100.00
Government						
Department of atomic energy	214	344	558	43.32	50.22	47.33
Department of space	84	95	179	17.00	13.87	15.18
Department of biotechnology	40	68	108	8.09	9.93	15.18
Department of S & T	37	33	70	7.49	4.82	5.94
Department of telecommunications	22	34	56	4.45	4.96	4.75
Ministry of power	20	30	50	4.05	4.38	4.24
Ministry of commerce	15	1	16	3.04	0.15	1.35
Ministry of water resources	12	4	16	2.43	0.58	1.35
Department of electronics	7	8	15	1.42	1.17	1.27
Ministry of health & family welfare	4	2	6	0.81	0.29	0.50
Others	39	66	105	7.89	9.63	8.90
Total	494	685	1179	100.00	100.00	100.00
Industries						
Private	163	261	424	64.17	77.91	71.98
Public	91	74	165	35.83	22.09	28.01
Total	254	335	589	100.00	100.00	100.00
State government	64	35	99	0.18	0.72	1.18
No. of records without any institutions	43	98	141	1.22	2.03	1.16
Grand total	3520	4829	8349	100.00	100.00	100.00

It is noticed that about 1000 institutions contributed a total of 8349 publications for the development of the engineering field. Major institutions contributing to the engineering field are Indian Institute of Science (IISc), Bangalore, Indian Institutes Technology (IITs), Bhabha Atomic Research Centre (BARC), Banaras Hindu University, etc. The Indian Institute of Science (IISc), Bangalore, ranked first with 490 (5.87%) publications, whereas Indian Institute of Technology, Delhi (4.86%) and Indian Institute of Technology, Madras (4.76%) are second and third, respectively. The five IITs together contributed 1627 articles, i.e., 19.49% of the total. The Indian Statistical Institute, Calcutta has 49 publications (14 in 1990 and 35 in 1994), i.e., 0.59% (at 33rd position) and the Indian Statistical Institute, Bangalore, has 2 publications in 1994; about 0.02%, at 400th position. From both years, it is also observed that most of the institutions produce only one single paper each.

Journal analyses

Journal analyses were carried out to determine

- a list of journals used by Indian engineers to publish their research output;
- a list of countries associated with the journals covered by COMPENDEX Plus in which Indian authors publish their articles;
- a list of Indian journals covered by COMPENDEX in 1990 and 1994 and used by Indian engineers.

Journals used

The source field in COMPENDEX was considered for analyses of the journals. The issue number, volume number, page number etc., were eliminated, while identifying the title. The country of origin for these journals are identified using *Ulrich's International Periodical Directory, Current Contents*, OPACs on INTERNET, etc. A program was executed which counts the number of records for each journal. The total number of papers for each journal and for both the years were calculated. The database was sorted according to total number of papers. Percentages for both the years and for the total were calculated. These results have been published elsewhere (*Dhawan and Arunachalam, 1998*).

Impact factor is one of the measures, which can be used to determine the quality of the journals. The impact factor of a journal is given by the ratio of the citations to the citable items published in that journal. The impact factors of the journals are taken from the *Journal Citation Reports (JCR) 1994* published by ISI, Philadelphia. The list of journals along with their IF and the countries of publication used by Indian researchers to publish their output are given elsewhere (*Dhawan and Arunachalam, 1998*).

It is to be noticed from the 1990 and 1994 data that 88% of the engineering output are published in 900 journals. Of 7352 papers, 5504 papers are covered by the SCI. This includes both Indian and non-Indian journals. Only four journals from Indian origin has an IF in the JCR. Table 7 gives the distribution of journals by IF.

Table 7
Distribution of journals by impact factors

Impact factor	No. of journals	Impact factor	No. of journals	Impact factor	No. of journals
0.000-0.100	24	0.401-0.500	52	0.801-0.900	21
0.101-0.200	53	0.501-0.600	33	0.901-1.000	23
0.201-0.300	41	0.601-0.700	27	1.01-2.00	103
0.301-0.400	51	0.701-0.800	25	>2.00	27
Total - 480					

The IF of four Indian journals are in the first four ranges, i.e., less than or equal to 0.400. From this we can infer that Indian engineers publish most of the literature in SCI covered journals. We also observed that Indian researchers used two journals with IF more than 6.000 - *Applied Catalysis* from the Netherlands (2 papers) and *Physical Review Letters* from USA (4 papers).

Publishing countries of the journals are also analyzed to find out in which country's journals Indian engineers publish their research output. In 1990 and 1994 Indian researchers have used 900 journals published from 27 different countries. 97% of the Indian literature are published in journals from USA, UK, Netherlands, India, Switzerland, Germany and Japan. 41% of the literature is published in journals from USA. 12% of the journals are from Indian origin.

The topmost 10 journals used by the Indian engineers for publications are:

1. *Bulletin of Materials Science* (IND) (IF=0.146)
2. *Journal of Applied Polymer Science* (USA) (IF=0.087)
3. *Journal of Materials Science Letters* (UK) (IF=0.444)
4. *Solid State Communications* (USA) (IF=0.446)
5. *Pramana: Journal of Physics* (IND) (IF=0.345)
6. *Microelectronics and Reliability* (USA) (IF=0.152)
7. *Journal of Materials Science* (UK) (IF=0.741)
8. *Computers and Structure* (USA) (IF=0.265)
9. *Physics and Superconductivity* (NLD) (IF=3.258)
10. *CWE: Chemical Engineering World* (IND) (IF=n.a)

Geographical distribution

The geographical distribution provides information on the city and state where research is going on, active in the subject field and their relative contributions to the field. To find out the geographic distribution of the institutions, the institutions are analyzed according to their locations. The database containing the city names is extracted. The database is then accordingly sorted. Misspelled city names are corrected. Then a program is executed to count the number of records in each city. The total and percentages records in each city for both years are calculated. Similarly a statewide analysis is also carried out. The list of Indian cities and states, contributing to the field of engineering and technology as seen from COMPENDEX database in 1990 and 1994, is given elsewhere (*Dhawan and Arunachalam, 1998*).

The first three positions by states are Maharashtra with 1283 records (15.38%), West Bengal with 1007 records (12.06%), and Delhi with 917 records (10.98%), respectively. Karnataka has moved from 6th position in 1990 to 4th position in 1994. From the two years of data, it may be observed that number of states with more than 1000 papers is 2, number of states with more than 100 papers is 10, while the rest of the states produce less than 100 papers.

It may be noticed from 1990 and 1994 that Indian engineers have used about 900 journals from 27 different countries; out of the 900 journals, only 553 and 718 were used in 1990 and 1994, respectively. 97% of the Indian literature are published in journals from USA, UK, The Netherlands, India, Switzerland, Germany and Japan. Of this, 41% of the literature is published in journals from USA. Table 8 gives the distribution of papers over countries.

Table 8
 Indian author's contributions to the periodical literature in engineering arranged by publishing country of the journal as seen from COMPENDEX database in 1990 and 1994
 (arranged according to total number of papers)

Rank	Country of publication	1990		1994		Total	Total %
		No. of journal	No. of articles	No. of journal	No. of articles		
1	USA	277	1326	348	1739	3065	41.689
2	UK	112	688	163	897	1585	21.559
3	IND	35	335	32	580	915	12.446
4	NLD	62	383	77	521	904	12.296
5	SWZ	21	148	26	235	383	5.209
6	GER	18	94	20	100	194	2.639
7	JPN	8	30	9	48	78	1.061
8	USSR	2	23	6	18	41	0.558
9	HUN	1	14	3	21	35	0.476
10	SING	0	0	1	26	26	0.354
11	NZL	1	16	1	8	24	0.326
12	CAN	4	10	6	12	22	0.299
13	THI	2	5	3	15	20	0.272
14	AUS	4	8	4	4	12	0.163
15	FRN	2	3	3	8	11	0.149
16	DEN	1	1	4	9	10	0.136
17	ISR	0	0	2	7	7	0.095
18	CHI	1	2	2	3	5	0.068
19	SA	1	2	1	2	4	0.054
20	IRE	0	0	1	3	3	0.041
21	Others	0	0	1	2	2	0.027
22	AFR	0	0	1	1	1	0.014
23	BEL	0	0	1	1	1	0.014
24	FIN	1	1	0	0	1	0.014
25	IRAN	0	0	1	1	1	0.014
26	MAL	0	0	1	1	1	0.014
27	PHI	0	0	1	1	1	0.014
Total		553	3089	718	4263	7352	100.000
Non journal items			431		558	989	
No. of records without any code for document type					8	8	
Total			3520		4829	8349	

Problems encountered

The following are some of the problems faced while carrying out this study. Some of the problems were also observed by *De Bruin* and *Moed* (1990) in their study on the unification of addresses in scientific publications.

1. In COMPENDEX Plus bibliographic database, there is no way to download all the information on Indian works using a single command/single step. To overcome this problem each field was searched along with publication year. For example SPY=1990 and Ti = (India or Indian) will retrieve all those titles which are dealing with India or Indian and published in 1990.
2. The word/phrase index search in "easy menu search" searches only the abstracts. The documents retrieved here may not be of Indian origin. These records were physically checked and those of Indian origin were selected. Deletion of abstracts in this case was a tedious and time-consuming process.
3. Lack of standardization in names of institutions and journals were observed in the downloaded records. For example, 11 different entries were found for the CSIR lab. In some cases, we found that for the same institutions many addresses were given. For example, Karnataka Regional Engineering College (KREC) had 3 addresses like K.R.E.C (Dharwad), K.R.E.C (Surathkal), K.R.E.C (). In such cases, it was difficult to identify the correct address of the institutions. It is also difficult to find out whether these are three different institutions or is a single one. However, in case of K.R.E.C different versions are treated as K.R.E.C (Surathkal). The abbreviations used are inconsistent. For example, the abbreviations used for national are natl, Nat etc., and for Department it is Dept and Dep. etc.
4. In some cases, we found that an important part of the field is missing. For example, in the author affiliation the institution name itself is missing.
5. Change in the institutional names was not incorporated in the COMPENDEX Plus database.
6. It was difficult to find out the place of publication for journals, therefore, we had to search many reference sources like *Ulrich's International Periodical Directory*, *Current Contents*, OPAC on INTERNET etc.
7. Incomplete information, missing information and errors in spelling are also some of the problems.

Summary and conclusion

The following are some of the conclusions drawn from the study of COMPENDEX Plus from 1990 and 1994:

1. The COMPENDEX Plus, an engineering bibliographic database, has covered 3520 and 4829 Indian publications in 1990 and 1994, respectively. It is observed in this study that 88% of the bibliographic records referred to articles of journals and the rest referred to proceedings of conferences, monographs, reports etc.
2. According to the COMPENDEX Plus bibliographic database, Indian engineers published their research results in English, Russian, German and French. It may be noticed from 1990 and 1994 that Indian authors have published most of the literature (20.62%) in chemical engineering, ceramics, plastics and polymers; the lowest number of documents (0.41%) was found in information science. At the global level, the maximum output (17.2%) was in the field of chemical engineering, ceramics, plastics and polymers and the minimum output (0.08%) was in the area of aeronautical and aerospace engineering. World's contributions in the field of chemical engineering has been decreased from 1990 to 1994.
3. About 46.96% of the Indian contributions were experimental in nature, while the remaining are in applications area (23.36%), theoretical and general reviews accounted for 15.79% and 10.99%, respectively.
4. About 1000 institutions contributed to the development of engineering and technology. It is noticed from the 1990 and 1994 data that 60% of the contributions were from the academic sector. Among the academic institutions, 40% were from the premier institutions.
5. Most of the articles/literature were published from New Delhi, Mumbai and Bangalore; leading states in engineering research are Maharashtra, West Bengal and Delhi.
6. Further, from the 1990 and 1994 data, it may be noted that Indian engineers used 900 journals to publish their research results. Out of the 900 journals, 47 were Indian journals. 12% of the journal articles were from Indian origin. Only 4 journals from Indian origin have an impact factor in the 1994 JCR. However, the impact factors of these journals are below 0.400.

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