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Sadhana – Academy Proceedings in Engineering Sciences: A scientometric analysis

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Abstract. This study presents a scientometric analysis of 253 articles published in Sadhana during the year 2005–2009. Five volumes of the journal are taken up to observe the distribution of contribution, authorship pattern, institution-wise distribution, geographical distribution of contribution, average length of paper, tables and illustrations used and citation pattern in each volume. Results indicate that highest number of papers have been written by two authors. The contributions received in this journal are more from India than from the other countries. Foreign documents show their more representation in references cited. Journals are referred more frequently than other documents.The average number of references per article is 23.72 and 200.602 per volume.

Keywords. Scientometrics; Engineering Sciences; authorship pattern; citation analysis; impact factor.

1. Introduction

The term scientometrics was adopted to cover the techniques applied to the quantification and analysis of scientific activities including the publication and organizing of books and journals (Brookes 1987). It is the study related to the measurement of science (Joshi 1988) that helps in identifying the progress of a particular science subject (Kaliyaperumal & Natarajan 2009). Scientometric tools can be used to measure and compare the scientific activities at various levels of aggregation including institutions, sectors, provinces and countries. They can also be used to measure research collaborations, to map scientific networks and to monitor the evolution of scientific fields. Scientometric indicators give policy-makers objective, reproducible and therefore verifiable information that goes beyond the anecdotal (http://www.science-metrics.com/eng/methods-scientometrics_t.htm). They forecast productivity of scientists so that dynamics of scientific research and technological development can be understood (Nattar 2009).

Reputed journals have been the focus of many bibliometric and scientometric studies for researchers. The journal of *Pramana*—(*Journal of Physics*) has been studied by Anil Kumar *et al*

for the publishing trends, impact factor, authorship pattern, keyword analysis and referencing pattern (Anil Kumar *et al* 2008). Author's co-citation analysis has been discussed by Hoffman and Holbrook for '*Journal of Consumer Research'* (Hoffman & Holbrook 1993).

Bibliometric techniques were used by Jill Crawley-Low to analyse the citation pattern of researchers publishing in the *American Journals of Veterinary Research* (*AJVR*) (Crawley-Low 2006). Lee (2009) has made an attempt to study the citation data of '*Korean journal of Parasitology*' retrieved from 4 major databases; SCI, Pub Med, Synapse, Scopus. Kalyane & Vidyasagar Rao (1992) have done the study of collaboration trends in Sugarcane research with the help of publications from Sugarcane Breeding Institute, Coimbatore. The studies by Kalyane and Sen; Hazarika, Goswami and Das; Rana and Agarwal; Verma, Tamrakar and Sharma; Jena are examples of bibliometric and scientometric analyses of journals for various periods (Rana Madan & Agarwal 1994; Kalyane & Sen 1995; Jena 2006; Hazarika *et al* 2003; Verma *et al* 2007).

Sevukan and Sharma have presented a detailed analysis of research performance of biotechnology faculties in central universities of India from 1997–2006 (Sevukan & Sharma 2008). Rajendran, Ramesh Babu and Gopalakrishnan analysed the global output of 'Fibre Optics' research from articles covered in the Ei-Tech Index database (Rajendran *et al* 2005). Kaliyaperumal and Natarajan discussed growth pattern and overall trend in literature output in retina during 2002–2007 using CD Rom sources of MEDLINE (Kaliyaperumal & Natarajan 2009). Surwase, Kademani and Vijai kumar attempted to highlight the neutron scattering research in India as per the number of publications appeared in the Scopus database (Surwase *et al* 2008). Garg Sharma and Suresh Kumar presented scientometric profile for the *Journal Mausam* by analysing different aspects of journal (Garg *et al* 2008).

2. Sadhana

Sadhana is a word of Sanskrit language means great perseverance or act performed with great perseverance. *Sadhana*: *Academy Proceedings in Engineering Sciences* is a bi-monthly research journal in English published by the Indian Academy of Sciences. The journal covers all branches of engineering science including mechanics (fluid, solid, thermal), computer science, electronics, energy, aerospace technology, materials science, nuclear engineering, system analysis, alternative technologies, etc. The journal focuses on papers that are relevant to more than one professional group, either because the work is fundamental or because it reflects the best in current technology. The journal also publishes summaries of special projects of interest to engineering scientists. The journal offers critical reviews, with an emphasis on subjects of particular interest in India. *Sadhana* is a standard journal in engineering science with a current impact factor 0.276 (2008), there is a need to examine, evaluate and document analysis of the scientometric parameters of the journal in detail. In its previous years, the journal had impact factors of 0.188 in 2007, 0.165 in 2006, 0.183 in 2005 and 0.144 in 1999. Overall, the journal shows its popularity among scientists (Journal Citations Reports 2009a, b; http://www.icast.org.in).

Sadhana also publishes special issues devoted to specific areas of Engineering Sciences. During 2005–2009 it has brought out nine special issues covering different topics of engineering sciences.

The journal abstracted/indexed in Academic search, Chemical Abstracts Service (CAS), Compendex, CSA/Proquest, Current Abstracts, Current Contents/Engineering, Computing and technology, Digital Mathematics Registry, Google Scholar, ICIDS, INIS Atomindex, Journal Citation Reports/Science Edition, OCLC, Science Citation Index Expanded (SciSearch),

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3. Objectives of the study

The following objectives were formulated for the present study.

(i) To find out volume-wise and issue-wise distribution of articles.
(ii) To examine authorship pattern.
(iii) To study geographical distribution of contribution at national and international level and analyse research productivity count of contribution on the basis of geographical distribution.
(iv) To study institution-wise distribution of contributions.
(v) To indicate physical growth and average length of papers.
(vi) To analyse the use of tables and illustrations.
(vii) To observe citation pattern analysis; references cited (national and international), bibliographical distribution of articles on the basis of different forms of documents used for cited references.
(viii) To study ranking of documents.

4. Methodology

The data for the study comprises the contributions in thirty issues of five volumes of '*Sadhana - Academy proceedings in Engineering Sciences* (2005–2009). The data pertaining to each of the 253 articles in volumes 30–34 in terms of authorship, number of pages, references cited in each issue and volume were noted. The data was then subjected to analysis as per the objectives of the study. All the analysed data is arranged and tabulated systematically for making observations.

5. Results and discussion

Table 1 shows that out of 253 contributions, 17.39% of them were contributed in 2005, 20.55% were published in 2006, 18.18% were published in 2007, 20.16% were contributed in 2008 and 23.72% were contributed in 2009. The study highlights a gradual increase in distribution of contributions from 2007 to 2009. The year 2009 has highest number of contribution with sixty articles (23.72%) and 2005 has the least number with forty four articles (17.39%). It is noted that number of articles varied year to year.

Table 2 portrays distribution of contributions issue-wise. There are combined issues in volumes 30 and 32. Volume 30 has numbers 2 and 3 issues in combined form and volume 32 has 1 and 2 in combination. Regarding volume 30 combined issues (2 and 3) shows more contribution than others. In volume 31, issue number 5 has the maximum number of contribution. In volume 32 combined issues (1 and 2) show more contributions. In volume 33, number 5 has maximum number of contributions and volume 34, issue number 4 records maximum number of contributions.

Table 1. Distribution of contributions volume-wise.

Year	Vol. no.	No. of issues	No. of contributions	%
2005	30	06	44	17.39
2006	31	06	52	20.55
2007	32	06	46	18.18
2008	33	06	51	20.16
2009	34	06	60	23.72
Total		30	253	100

Table 2. Distribution of contributions issue-wise.

	Volume no.				
Month	30	31	32	33	34
Jan–Feb	6	7		5	5
March–April		6	13	3	9
May–June	18	7	9	13	10
July–Aug	8	11	11	6	15
Sep–Oct	6	12	10	17	11
Nov–Dec	6	9	3	7	10
Total	44	52	46	51	60

Table 3 shows the authorship pattern of contribution. Out of 253 articles 33.99% of articles were contributed by two authors followed by 31.23% by three authors, 15.81% by single author, 13.04% by four authors and 5.93% by five or more authors. A significant note of the study is that the majority of the articles (84.19%) were contributed by two or more authors. It shows more collaboration in research work.

Table 4 explains the authorship pattern of contributions volume-wise. Regarding contributions by single author, the volume number 31 records the highest percentage (27.5%). Regarding two authors contributions, the volume 32 shows maximum percentage (25.58%). Regarding three authors contributions, the volume 33 shows the highest percentage (31.65%). Regarding four authors contributions, the volume number 34 reflects maximum percentage (27.27%). Regarding five or more authors contributions, the volumes 32 and 34 have highest percentage (26.67%). The research shows that the trend is pointing towards multi-authorship.

Table 3. Authorship pattern of contributions.

No. of authors	No. of contributions						
	2005	2006	2007	2008	2009	Total	%
Single author	6	11	8	5	10	40	15.81
Two authors	17	19	22	12	16	86	33.99
Three	10	13	10	25	21	79	31.23
Four	8	6	2	8	9	33	13.04
Five or more	3	3	4	1	4	15	5.93
Total	44	52	46	51	60	253	100

Table 4. Authorship pattern of contributions (volume-wise).

Vol. no.	Single author	%	Two authors	%	Three authors	%	Four authors	%	Five or more authors	%
30	6	15	17	19.77	10	12.66	8	24.24	3	20
31	11	27.5	19	22.1	13	16.46	6	18.18	3	20
32	8	20	22	25.58	10	12.66	2	6.06	4	26.67
33	5	12.5	12	13.95	25	31.65	8	24.24	1	6.67
34	10	25	16	18.60	21	26.58	9	27.27	4	26.67
	40	100	86	100	79	100	33	100	15	100

Table 5 depicts the distribution of contributions institution-wise. Out of 253 articles contributed, 108 articles are from institutions followed by universities having 98 articles and others having 47 articles. It is inferred that institution-wise contributions were the maximum (42.68%).

Table 6 explains that total contribution from India were 164. The study of 164 articles revealed that first position of Karnataka State with contribution of 34.15%. Contributions from Tami Nadu, Maharashtra, New Delhi and West Bengal were fairly good and rest of the states

Table 5. Contributions institution-wise.

Volume no.	Year	Institution	University	Miscellaneous	Total
30	2005	17	19	8	44
31	2006	21	24	7	52
32	2007	21	9	16	46
33	2008	25	18	8	51
34	2009	24	28	8	60
Total		108	98	47	253
%		42.68	38.74	18.58	100

Table 6. Geographical distribution of contribution in India (state-wise).

Sl. no.	Name of the state	No. of contributions	%
1	Karnataka	56	34.15
2	Tamil Nadu	19	11.58
3	Maharashtra	18	10.97
4	New Delhi	18	10.97
5	West Bengal	16	9.76
6	Madhya Pradesh	7	4.27
7	Andhra Pradesh	6	3.66
8	Haryana	6	3.66
9	Uttar Pradesh	5	3.05
10	Assam	4	2.44
11	Jharkhand	3	1.83
12	Uttarakhand	2	1.22
13	Gujarat	1	0.61
14	Kerala	1	0.61
15	Pondicherry	1	0.61
16	Punjab	1	0.61
Total		164	100

shared less percentage. The study shows that Karnataka dominates other states in the number of contributions.

Table 7 shows out of 253 contributions, 64.82% came from India followed by 14.22% from Turkey, 3.56% came from USA. Countries like UK, Singapore, Croatia, Iran, Malaysia, Netherlands and Taiwan have made contribution less than 3%. Rest of the countries have less than 1% of total contributions.

Table 8 depicts that 60 research articles covered 1080 pages (2009); 51 articles covered 846 pages (2008); 44 articles covered 786 pages (2006) and 46 articles covered 704 pages (2007). The study observed that in the year 2009 articles covered maximum number of pages as well as with highest average number of pages.

Table 7. Geographical distribution of contribution at international level.

Sl. no.	Name of the country	No. of contributions	%
1	India	164	64.82
2	Turkey	36	14.22
3	USA	9	3.56
4	UK	5	1.97
5	Singapore	4	1.58
6	Croatia	3	1.18
7	Iran	3	1.18
8	Malaysia	3	1.18
9	Netherlands	3	1.18
10	Taiwan	3	1.18
11	Australia	2	0.79
12	China	2	0.79
13	Saudi Arabia	2	0.79
14	Switzerland	2	0.79
15	Germany	2	0.79
16	Austria	1	0.40
17	Bulgaria	1	0.40
18	Canada	1	0.40
19	Egypt	1	0.40
20	Italy	1	0.40
21	Korea	1	0.40
22	Norway	1	0.40
23	Portugal	1	0.40
24	Romania	1	0.40
25	Serbia	1	0.40
Total		253	100

Table 8. Average pages (per volume and per contribution).

Year	Volume no.	Total pages	No. of articles	Average
2005	30	786	44	17.46
2006	31	782	52	15.04
2007	32	704	46	15.30
2008	33	846	51	16.59
2009	34	1080	60	18.00

Table 9 reveals that 36.36% of papers covered 11–15 pages followed by 24.5% of papers covered 6–10 pages, 18.18% of papers covered 16–20 pages, 10.28% of papers covered 21–25 pages, 5.14% of papers covered 26–30 pages, 4.35% of papers covered more than 30 pages and 1.19% of papers covered 1–5 pages. The study shows that out of 253 articles, 188 articles covered more than 10 pages, thus the average length of articles is good enough.

Table 10 shows the number of tables used in articles. Out of 253 articles, 41.5% of articles have no tables. 31.23% of them having 1–2 tables, 12.25% having 3–4 tables, 9.49% articles having 5–6 tables, 3.16% articles having 7–8 tables, 1.97% articles having more than 10 tables and 0.4% articles having 9–10 tables. The study finds out that approximately half of the numbers of contributions have no tables and 79 articles did not use them frequently.

Table 11 shows that 42.29% of papers having 6–10 illustrations followed by 24.9% of papers having 1–5 illustrations, 15.42% of papers having 11–15 illustrations, 8.69% of papers having 16–20 illustrations, 5.93% of papers having no illustrations, 1.58% of papers having 21–25 illustrations, 0.79% of papers having 26–30 illustrations, 0.4% of papers having more than 30 illustrations. The study shows that out of 253 articles, 238 articles were illustrated finely.

Table 12a shows the distribution of citations in the articles. Study explains that there are a total of 6018 citations distributed among 253 articles. Out of these 85.13% references were cited from foreign documents whereas 14.87% were cited from Indian documents. Citations used from international sources are prominent.

It has been found that like number of articles, the number of citations per year is varying from year to year. Table 12b shows that the highest number of citations were used in the year 2009

Table 9. Average length of paper.

No. of pages	2005	2006	2007	2008	2009	Total	%
1–5	nil	1	nil	1	1	3	1.19
6–10	10	13	16	11	12	62	24.5
11–15	12	24	16	19	21	92	36.36
16–20	11	6	8	10	11	46	18.18
21–25	4	6	4	6	6	26	10.28
26–30	4	2	nil	2	5	13	5.14
30<	3	nil	2	2	4	11	4.35
Total	44	52	46	51	60	253	100

Table 10. Occurrence of tables in the articles.

No. of data tables	2005	2006	2007	2008	2009	Total	%
Nil	13	29	22	19	22	105	41.5
1–2	16	14	12	19	18	79	31.23
3–4	8	4	4	7	8	31	12.25
5–6	5	1	4	5	9	24	9.49
7–8	1	3	2	1	1	8	3.16
9–10	nil	nil	1	nil	nil	1	0.4
10<	1	1	1	nil	2	5	1.97
Total	44	52	46	51	60	253	100

Table 11. Occurrence of illustrations in the articles.

No. of illustrations	2005	2006	2007	2008	2009	Total	%
Nil	5	5	1	2	2	15	5.93
1–5	16	9	13	7	18	63	24.90
6–10	17	27	16	19	28	107	42.29
11–15	4	7	9	12	7	39	15.42
16–20	1	3	6	8	4	22	8.69
21–25	Nil	1	1	1	1	4	1.58
26–30	1			1		2	0.79
30<				1		1	0.4
	44	52	46	51	60	253	100

Table 12a. Citation pattern of articles (national and international).

Year	National	International	Total
2005	182	1109	1291
2006	151	783	934
2007	240	839	1079
2008	133	753	886
2009	189	1639	1828
Total	895	5123	6018
%	14.87	85.13	100

Table 12b. Citation pattern of articles (average citations used).

Year	No. of articles	Cumulative total of articles	No. of citations	Cumulative total of citations	Average citations per paper	Cumulative average of citations	Average citations per journal issue
2005	44	44	1291	1291	29.34	29.34	215.17
2006	52	96	934	2225	17.96	23.18	155.67
2007	46	142	1079	3304	23.46	23.27	179.83
2008	51	193	886	4190	17.37	21.71	147.67
2009	60	253	1828	6018	30.47	23.79	304.67
Average in five years					23.72		200.602

(1828) and lowest in 2008 (886). The highest average of citations per article was in the year 2009 and the lowest number of citations per paper was in the year 2008. Likewise, the highest average of citations per journal issue was in the year 2009 and the lowest average of citations per journal issue in the year 2008. From the analysis of citations per paper and per volume in five years, the averages are found to be 23.72 and 200.602, respectively.

Table 13a represents year-wise bibliographical distribution of citations. The bibliographical forms of citations were divided into different categories as journals, books, proceedings reports, thesis, manuals, standards, electronic media and others. Table 13b represents the ranking of documents. From these tables it has been seen that 'journals' are cited predominantly in all the years followed by 'books'. Out of the total citations, journals constitute 57.59% whereas books constitute 16.74% and proceedings constitute 14.15%. Rest of the forms constitute less than 5%

Table 13a. Bibliographical distribution of articles.

Year	Journals	Books	Proceedings	Reports	Thesis	Manual	Standards	Electronic media	Others	Total
2005	683	254	149	66	20	4	2	65	48	1291
2006	547	181	117	18	13	4	4	5	45	934
2007	616	145	169	38	21	4	5	8	73	1079
2008	539	184	110	12	12	1	0	16	12	886
2009	1081	244	307	30	61	3	8	65	29	1828
Total	3466	1008	852	164	127	16	19	159	207	6018

Table 13b. Ranking of documents.

Sl. no.	Rank	Bibliographic form	No. of cumulative	% of citations
1	1	Journals	3466	57.59
2	2	Books	1008	16.74
3	3	Proceedings	852	14.15
4	4	Reports	164	2.72
5	5	Electronic Media	159	2.64
6	6	Thesis	127	2.11
7	7	Standards	19	0.35
8	8	Manual	16	0.26
9		Others	207	3.44
Total			6018	100

citations each viz. reports constitute 2.72%, electronic media 2.64%, thesis 2.11%, standards 0.35%, manuals 0.26% and others have 3.44%. Other forms of documents used are summaries, personal communication, paper series, special publications, statistics, research notes, bulletins, monographs, data tables, lecture notes, datasheets, surveys and tutorials, etc.

Table 14 shows the details of special issues published each year. Except 2005 each year has been published two special issues covering different topics of engineering science.

Table 14. Special issues.

Year	Month	Volume	Issue	Title
2005	April–June	30	2&3	Electronic e-commerce and electronic business
2006	April	31	2	Statistical techniques in electrical and computer engineering
2006	August	31	4	Probabilistic structural dynamics and earthquake engineering
2007	Feb–Apr	32	1&2	Flow control and diagnostics
2007	August	32	4	Transportation research safety and sustainability
2008	June	33	3	Friction, fretting and wear: Engineering materials and technologies
2008	October	33	5	Power electronics
2009	February	34	1	Interaction theorem proving and verification
2009	August	34	4	Microelectronics systems (MEMS)

6. Conclusion

Sadhana is a reputed journal in the field of engineering science. It covers all aspects of engineering science. Its special issues present state-of-the art research and are useful to researchers. The present study clearly shows the trend towards collaborative research. International sources of information used predominantly for referencing. Authors referred to a wide variety of reference sources of information where journals used very frequently. Majority of contributions are from India and Karnataka State represents first place among other states. Volume 34 has highest number of articles. Number of contributions received from Indian Institutes of Technology, Institutes of Technology, Research Institutes, Institutes of Technology and Science, Indian Institute of Science are more when compared to universities and others. Length of papers and use of illustrations are well-represented. Illustrations contain photo prints also and *Sadhana Journal* showcases progress of research in the field of engineering science.

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