

SCIENTOMETRIC PORTRAIT OF VIKRAM AMBALAL SARABHAI: A CITATION ANALYSIS

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The paper analyses the citations to the publications of Vikram Sarabhai, using Science Citation Index 1944-1991 as the source for data. The extent of citations received, in terms of the number of citations per paper and the categories of citing documents and the distribution of citations among them are determined. Analysing the year-wise break up of citations, the peak periods are identified. The extent of citations to the papers in each domain and the citation pattern in relation to the status of authorship are examined. Types of documents citing Sarabhai's publications are identified. The citing journals are identified and ranked list of them is prepared. Distribution of citations and citing journals according to disciplines are made to assess the impact of Sarabhai's research on other disciplines. By studying the distribution of citations among journals, the Bradford Multiplier is calculated and Bradford-Zipf citograph is plotted. Ten highly cited papers of Sarabhai have been identified. Prominent scientists citing Sarabhai's publications are identified. The time-lag between publication of a paper and it receiving its first citation is estimated.

KEYWORDS/DESCRIPTORS: Citation analysis ; Scientometrics; Individual scientist; Self-citations; Citation concentration; Citation impact; Citation time-lag; Scientometric portrait; History of science; Sociology of science

1 INTRODUCTION

In recent days, individual scientist has become a focus of scientometric studies [1-16]. Vikram Sarabhai, the noted Indian space

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scientist ,who contributed a lot to the Indian space programme is considered as role model scientist for the younger generation to emulate. His contributions in the field of cosmic rays has been well accepted by the scientists both at national and international levels. His contribution to management and science policy and national development disciplines has been described by Kademani and Kalyane [12]. Significance of this contribution is evident from the citations that his publications have received in Indian and foreign learned journals.

Citation analysis is now -a-days considered as a very effective technique to measure the scientific activity, utility and impact of scientific output of individual scientists,institutions and nations. The present study attempts to highlight the scientific contributions of Vikram Sarabhai by way of citation analysis.

2 OBJECTIVES

The objectives of the present study are:

- to identify the extent of citations received to the publications of Vikram Sarabhai and the types of documents citing them,
- to find out quinquennial citations to publications of Vikram Sarabhai,
- to differentiate the citation pattern with his position in authorship of the cited articles,
- to find out the distribution of articles on the basis of citedness in domains to which he has contributed,
- to identify top ranking papers of Vikram Sarabhai,
- to ascertain the characteristics of citing documents and to prepare a ranked list of citing journals,
- to examine the scattering of citations among journals and to estimate the Bradford Multiplier,
- to draw Bradford-Zipf citograph,
- to identify the influence of Sarabhai's research on other disciplines,

- to calculate time-lag between publication of a paper and it getting its first citation, and
- to identify core peer citing group.

3 METHODOLOGY

Research is a complicated process involving many intricate issues, and evaluation of scientific activity is still more complicated. Evaluating science has become a major aim for those dealing with decision making for the management of science. Martin and Irvin [17] have thoroughly reviewed about the basic research inputs and outputs and various possible assessment methods and considered the count of scientific publications and citations, and peer evaluation as methods providing characteristic indicators. Laharia and Singh [18] have discussed the various approaches used to measure the scientific productivity, and Lancaster [19] has suggested bibliometric measures of productivity and impact in research.

The citation analysis technique has been adopted for the present study. Citation brings out the connection between two documents; the one which cites and the other which is cited. The act of citing in general, an expression of the importance of the material cited, as authors often refer to previous material to support, illustrate or elaborate on a particular point [20 - 21]. A highly cited work, naturally, is the one that has been found to be useful by relatively large number of authors, or in relatively large number of experiments. Citation count is therefore, a measure of scientific activity, utility and impact of scientific work. However, citation counts do not say anything about the nature, utility or impact of the work [22].

Citation analysis constitutes an important tool in quantitative studies of science and technology. To assess the quality of a given publication, the number of times it has been cited in the literature can be counted. Similarly, the number of times a person has been cited in the

literature can be taken as a measure of the quality of that person's work [23-30].

Citation analysis is a more complex task than is often recognized in the sense that it requires careful identification of exactly what is being analysed. Every citation represents a decision of the author to draw attention to the work of another as being relevant to his theme at a particular point in the document he is writing [31]. Citation counts not only help a research administrator to assess the quality of each individual scientist but also that of his organization as a whole. A few studies of this sort on individual scientists have been conducted [32-44].

The unit of study in citation analysis can be any form of written communication or an author, an organization or a nation [45]. However, citation counts cannot be taken as the sole measure of quality, because numerous other factors affect scientists' work and the impact of their publications is only a measure of their overall influence. For instance, a scientist who spends most of his time on teaching may contribute in an indirect way to the future achievements of his institution. Sometimes a scientist may require years of background work to prepare a paper and that single paper itself would be a vital contribution having more value than that of publications of other prolific authors. Nevertheless, policy makers and scientists themselves are almost invariably keen to see this kind of information [46-50]. One should be very careful while collecting and carrying out citation analysis as it may contain some discrepancies [51-52]. Liu [53] reviewed on the citation studies that have dealt with citation functions, citation quality, citation concept and citation motivation. Citation analysis as a subject remains controversial [54]. Rousseau [55] proposed a framework within which citations can be used for evaluation purposes.

For the present study, a bibliography of the publications of Vikram Sarabhai was compiled and each item was subjected to manual scores for citations received as per Science Citation Index (1944-1991) published by the Institute for Scientific Information, Philadelphia. Bibliographical data of both cited and citing papers were collected on formats designed for the purpose. The data obtained were then analysed and the results are summarized in the subsequent sections.

4 RESULTS AND DISCUSSION

Vikram Sarabhai's scientific career spanned over 28 years. During 1944-1971 he had contributed 160 publications in the domains 'Cosmic Rays'(89), 'Science Policy and National Development' (57), and 'Management' (14). An analysis of the publication productivity of Vikram Sarabhai has been carried out separately by Kademani and Kalyane[12].

4.1 Extent of Citations and Categories of Citing Documents

Vikram Sarabhai became citable contributor with his original contributions in the field of 'Cosmic Rays' in 1947 and 'Science Policy and National Development' in 1964. He had received total 533 citations in the domain; 'Cosmic Rays' (518), and 'Science Policy and National Development'(15).

Types of publications citing publications of Vikram Sarabhai are given in Fig.1. Journal articles have cited publications of Sarabhai 391 times which is 73.36 percent of total citations. Reviews have cited 62 times which is 11.64 percent.

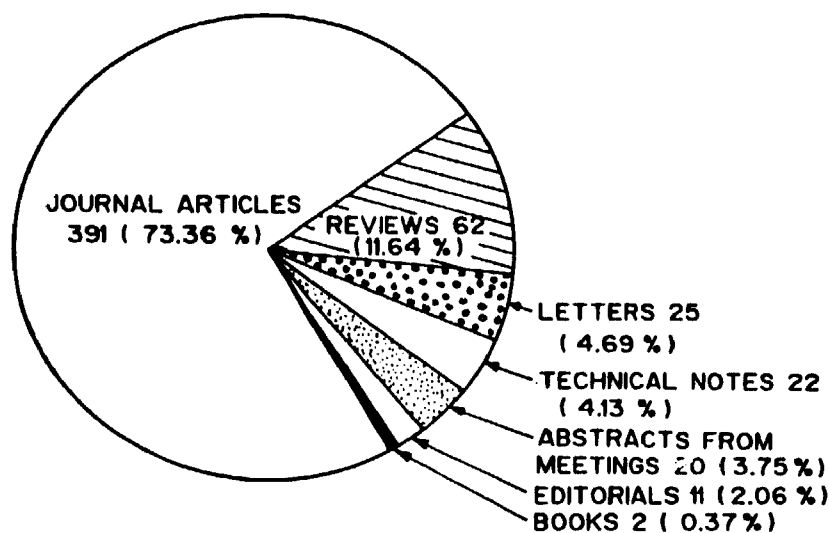


Fig. 1 Types of Documents Citing Vikram Sarabhai

4.2 Yearwise Break up of Citations

Quinquennial citations to publications of Vikram Sarabhai are provided in Fig. 2. The maximum number of citations 78, 44, and 34 were received in 1971, 1972, and 1970 respectively. Highest number of citations (197) were received during 1968-72. Mean citations per year were 12.11.

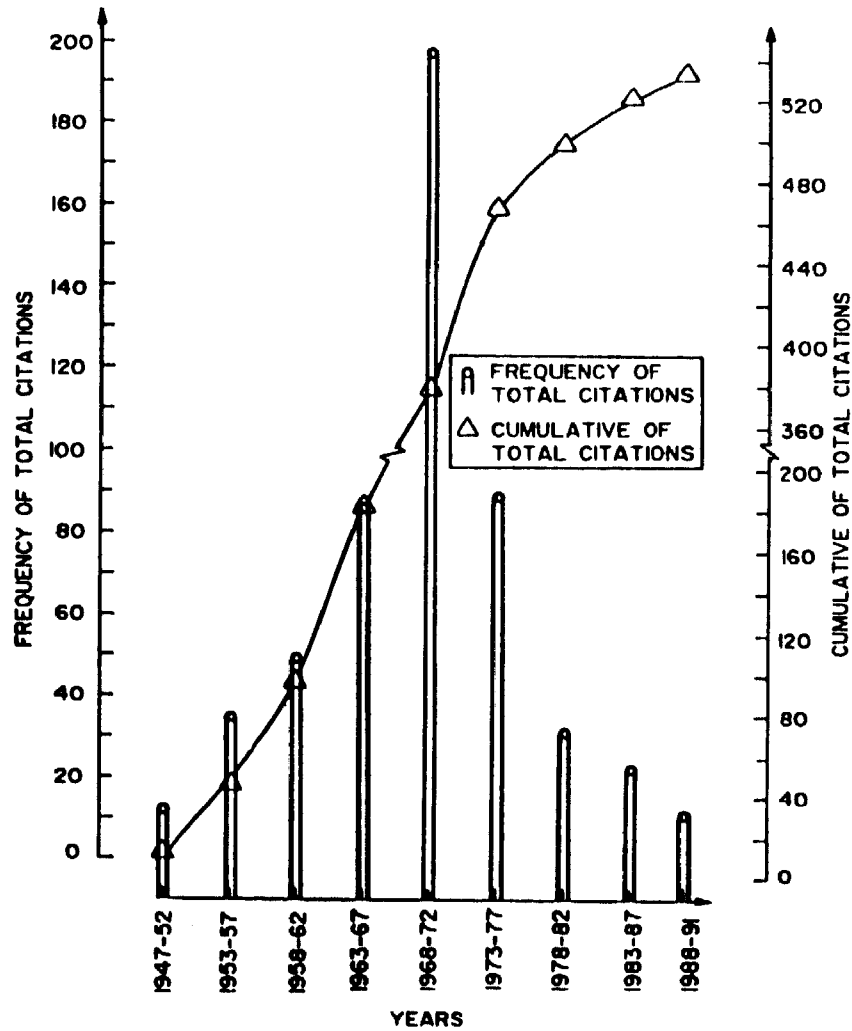


Fig. 2 Quinquennial Citations to Publications of Vikram Sarabhai

Quinquennial team-self citations and citations by others to publications of Vikram Sarabhai are provided in Fig. 3. Total team-self citations were 169 (37.70%). Highest total team-self citations were found in 1971, 1972, and 1970 having 29, 16, and 15, citations respectively. Highest team-self citations(67)were found during 1968-72. For cosmic rays domain, Diachronous Rate was 14(n=51), and Synchronous Rate was 16.5 (n=30).

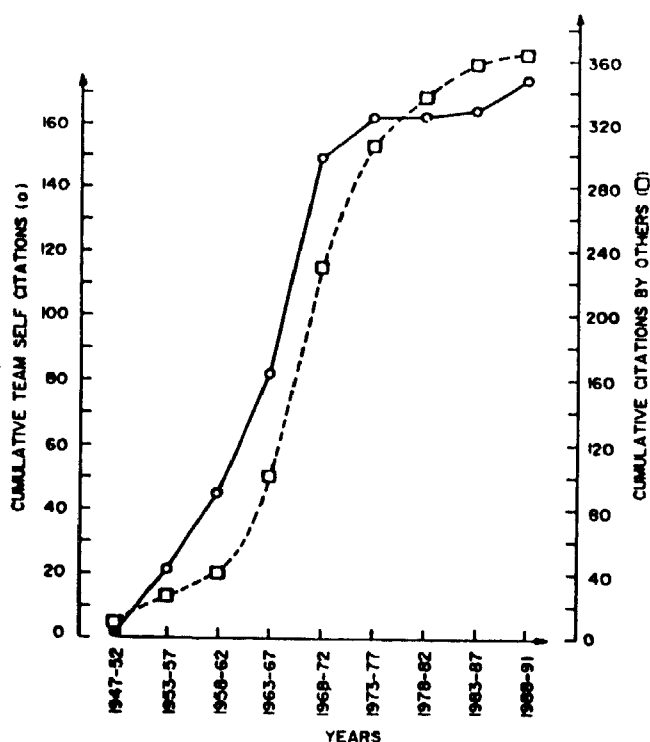


Fig. 3 Quinquennial Team Self Citations and Citations by Others

Total citations other than team -self citations were 364 (68.30 %). Three peaks of high citations by others were found in 1971, 1972, and 1973 having 49, 28, and 20 citations respectively. Highest citations(130) by others were found during 1968-72. It is evident from the Fig.3 that the trend of citation rates by others is almost the double of team self -citation rates.

'Team self-citation' is defined as the citations to the publications of an author by any member of his research team or by himself. The practice of citing oneself is both common and reasonable. Studies show that at least 10% of all citations are self-citations, in which he or she is the principal author. The percentage would be much higher if authors other than principal author in the cited documents are also taken into consideration. Since scientists tend to build on their own work, and the works of their collaborators, a high self-citation count more often than not, indicates nothing more ominous than a narrow speciality [21].

4.3 Domains of Specialization

Vikram Sarabhai had contributed significantly to two major domains namely 'Cosmic Rays' and 'Science Policy and National Development' during the period under study. The citation rates may be influenced by domain, channels of communications used, number of researchers collaborating, number of researchers working in the field and duration of research.

The distribution of articles on the basis of citedness in 'Cosmic Rays' is shown in Table 1. Total citations to his publications in this domain were 518. Mean citations per paper in this domain were 5.8.

Table 1. Distribution of Articles on the Basis of Citedness in 'Cosmic Rays'

Citedness of articles (No. of times)	No. of articles	No. of citations	Cumulative No. of citations
0	29	0	0
1	13	13	13
2	7	14	27
3	5	15	42
4	3	12	54
5	5	25	79
6	2	12	91

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Citedness of articles (No. of times)	No. of articles	No. of citations	Cumulative No. of citations
7	2	14	105
8	2	16	121
9	3	27	148
10	2	20	168
11	2	22	190
12	1	12	202
13	1	13	215
15	2	30	245
16	2	32	277
18	1	18	295
23	1	23	318
25	1	25	343
26	3	78	421
35	1	35	456
62	1	62	518

Similarly Table 2 shows total 15 citations to domain 'Science Policy and National Development'. Mean citations per paper in this domain were 3.8.

**Table 2 Distribution of Articles on the Basis of Citedness in
'Science Policy and National Development'**

Citedness of articles (No. of times)	No. of articles	No. of citations	Cumulative No. of citations
0	49	0	0
1	6	6	6
2	1	2	8
3	1	3	11
4	1	4	15

Out of 89 papers in the domain 'Cosmic Rays' 29 papers remained uncited. Similarly out of 57 papers 49 papers remained uncited in the domain of 'Science Policy and National Development'.

4.4 Citation Pattern vs Status of Authorship

The number of citations received to the publications of Vikram Sarabhai in relation to his position in authorship is shown in Fig. 4. His single authorship papers had received 98 (18.39 %) citations. His first authorship papers (in multi author papers) had received maximum 227 (42.59 %) citations. The collaborative papers wherein Sarabhai was co-author only (not first author) had received 208 (39.02 %) citations.

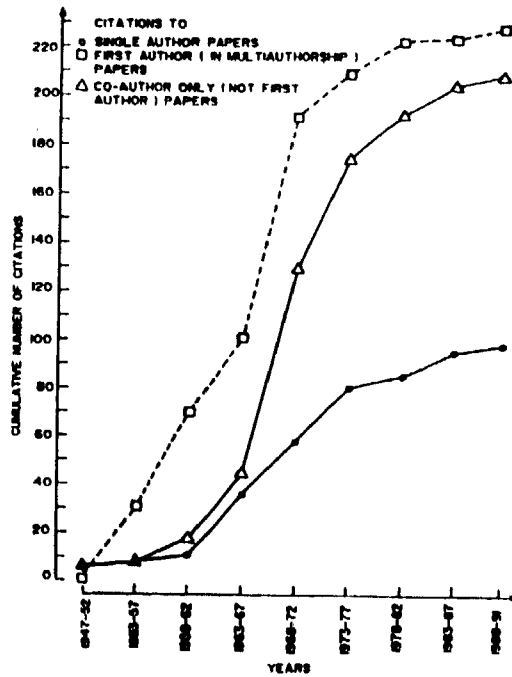


Fig. 4 Citations Received to Papers of Vikram Sarabhai with his position in Authorship

Authorshipwise distribution of papers and citations in 'Cosmic Rays' is provided in Table 3. Maximum 337 citations were for two authored publications. Three authored publications have received 88

citations and single authored publications have received 84 citations. This clearly indicates that multiauthorship papers are highly cited which represent high quality work due to collaborations. Researchers tend to co-operate but their co-operation is narrowed down due to personal interests of deeper specialization. Researchers do not work alone but they prefer to share more with their likes than with those who differ greatly in the training acquired as well as in their profession [56]. The general trend all over is towards multiauthorship papers [57]. Quality gain, calculated as the ratio of the number of citations to multiauthored papers to the number of citations to single authored papers is 2.31.

Table 3. Authorshipwise Distribution of Papers and Citation 'Cosmic Rays'

Authorship	No. of papers published	No. of citations received	Citations/paper
Single	15	84	5.6
Two	50	337	6.7
Three	19	88	4.63
Four	4	7	1.75
Six	1	2	2.00
Total	89	518	5.82 Ave.

Jointly authored papers tend to be cited more than others. In fact, the more authors a paper has, the more likely it is to be cited. For the field of cancer research, Lawani [58] has shown clearly that citation rate and quality of paper, as judged by a form of peer review, both correlate positively with the number of authors per paper.

4.5 Highly Cited Papers of Vikram Sarabhai

Ten highly cited papers of Sarabhai could be identified as these papers have received more than 50 percent of the total citations to all papers. Citograph for these ten highly cited papers is given in Fig.5. Bibliographic details of these papers are given in Appendix 1.

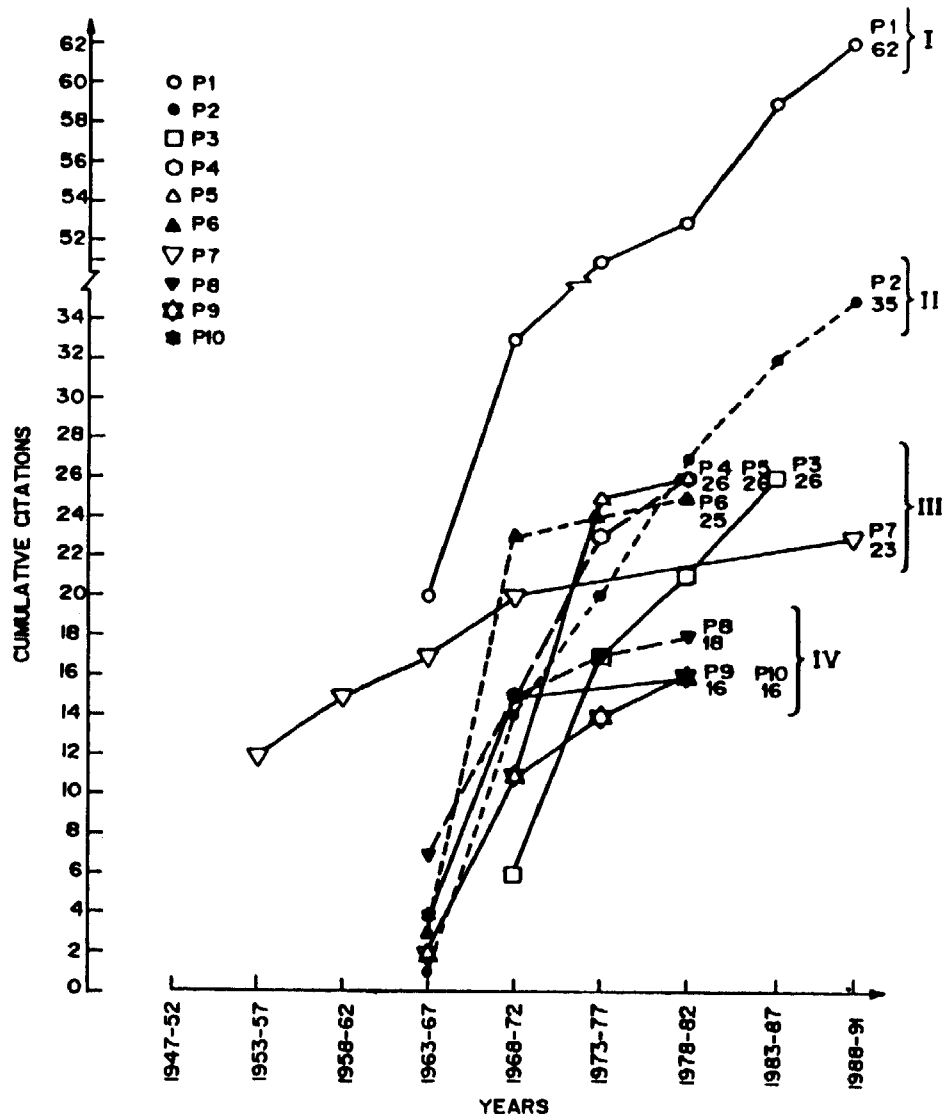


Fig. 5 Citations to Ten Top Ranking Papers of Vikram Sarabhai

We can classify Sarabhai's papers into five groups. First group (P1) receiving highest citations (62) forms one distinct group. The paper (P2) receiving medium citations (35) forms second group. Third group consists of papers P3, P4, P5, P6, and P7. Fourth group consists of papers

P8, P9, and P10. Other papers receiving lower citations can be classified into fifth group.

The paper P1 has received total 62 citations, out of which 11 are team self-citations. This paper has received citations in the same year of its publication and continue to receive till 1991 the period under study. It has received six citations each in 1964, 1965, and 1973. The paper P2 has received 35 citations out of which six are self-citations. The paper P3 has received total 26 citations out of which two are team self-citations. This paper attracted citations after a year of its publication and no citations after 1986 till 1991. The paper P4 has received total 26 citations out of which nine are team self-citations. This paper received citations after a year of its publication. The paper P5 has received total 26 citations out of which six are team self-citations. This paper received citations in the same year of its publication. The paper P6 has received total 25 citations out of which five are team self-citations. This paper attracted citations after a year of its publication. There are no citations after 1972 for this paper till 1991. The paper P7 has received total 23 citations out of which 14 are team self-citations and it attracted citations in the same year of its publication and continued to receive citations till 1990. The paper P8 has received 18 citations out of which two are team self-citations. This paper received citations after two years of its publication. It has received no citations after 1981. The paper P9 has received total 16 citations out of which three are team self-citations. There are no citations after 1972 till 1991. This paper received citations after two years of its publication. The paper P10 has received total 16 citations out of which three are team self-citations. There are no citations after 1972 till 1991. This paper received citations in the same year of its publication.

4.6 Core Citing Group

Core authors citing Sarabhai's publications (Table 4) include U.R. Rao (36), R.P.Kane (36), L .I. Dorman(21), K. Nagashima (14), M.A. Pomerantz(14), H.S.Ahluwalia (11), P.N.Pathak (10), and G.Subramanian (10).

Table 4 Prominent Authors citing more than five times Sarabhai's publications

Sl. No.	Name of citing authors	No. of times cited	Percentage
1	Sarabhai, V.	45	8.44
2	Rao, U.R.	36	6.75
3	Kane, R.P.	35	6.56
4	Dorman, L.I.	21	3.93
5	Nagashima, K.	14	2.62
6	Pomerantz, M.A.	14	2.62
7	Ahluwalia, H.S.	11	2.06
8	Pathak, P.N.	10	1.87
9	Subramanian, G.	10	1.87
10	Messerschmidt, W.	8	1.50
11	Venkatesan, P.	8	1.50
12	Kolomeets, E.V.	7	1.31
13	Parker, E.N.	7	1.31
14	Owens, A.J.	6	1.12
15	Patel, D.	6	1.12
16	Dhanju, M.S.	5	0.93
17	Jokipii, J.R.	5	0.93
18	Parker, G.D.	5	0.93
19	Pratap, R.	5	0.93

4.7 Scattering of Citations and Bradford's Law

Total 75 journals and two books have cited the publications of Vikram Sarabhai. Citation density was 6.92 and citation concentration was 10.38.

In the highest impact factor (22.132) journal Nature, Sarabhai had received 10 citations. He had received 21 citations in the journal Astrophysical Journal having 2.931 impact factor. He had received 58 citations in Journal of Geophysical Research having impact factor 2.100, 52 citations in Planetary and Space Science having impact factor 1.075, and 45 citations in Space Science Reviews having impact factor 1.857.

When application of Bradford's law to the citation data (Table 5) was studied, average Bradford Multiplier found was 2.73. The most citing three journals appear in the first zone were Journal of Geophysical Research (58), Planetary and Space Science (52), and Space Science Reviews (45).

Table 5. Ranked list of Journals citing Vikram Sarabhai

Sl. No.	Title of Journal	No. of citations	Percentage	Cumulative percentage	Impact Factor	Immediacy Index	Coverage in No. of A&I Journals
1	J.Geophys.Res	58	10.88	10.88	2.100	0.900	-
2	Planet Space sci.	52	9.75	20.63	1.075	0.259	9
3	Space Sci. R.	45	8.44	29.07	1.857	0.358	9
4	Ian.SSS.Fiz.	27	5.06	34.13	-	-	-
5	Rep. Ion. Spa.	24	4.51	38.64	-	-	-
6	Astrophys. J.	21	3.93	42.57	2.931	0.152	10
7	Solar Phys.	21	3.93	46.50	1.301	0.245	10
8	Can. J. Phys.	19	3.56	50.06	0.461	0.099	29
9	J. Geophys.R.S.P.	18	3.37	53.43	-	-	-
10	Phys. Rev.	18	3.37	56.80	-	-	14
11	J. Atm.Ter. P.	12	2.25	59.05	-	-	11
12	J.Sci. Ind. R. -A	11	2.06	61.11	0.062	0.033	37
13	P.R. Soc.-A	11	2.06	63.17	-	-	-
14	J.Geomag. G.	10	1.88	65.05	0.333	0.455	12
15	Nature	10	1.88	66.93	22.139	5.224	87
16	Nuov. Cim.-B	10	1.88	68.81	0.408	0.075	-
17	Ann. R. Nucl.	9	1.68	70.49	-	-	15
18	Nuov.Cim.	9	1.68	72.17	-	-	-
19	Ann. Geophys.	8	1.60	73.77	1.162	0.275	-
20	Astro.Sp. Sc.	7	1.31	75.08	0.325	0.155	11
21	Rev. Geophys.	7	1.31	76.39	1.308	0.688	13
22	Geomag. Aer.	6	1.12	77.51	0.156	0.074	9
23	J. Sci. Ind. R.	6	1.12	78.63	-	-	37

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Sl. No.	Title of Journal	No. of citations	Percentage	Cumulative percentage	Impact Factor	Immediacy Index	Coverage in No. of A&I Journals
24	P.Phys.Soc.	6	1.12	79.75	-	-	-
25	Usp. Fiz. Nau.	6	1.12	80.87	1.343	0.373	10
26	Current Sci.	5	0.93	81.80	0.253	0.075	45
27	Geophys. R. L.	5	0.93	82.73	1.937	0.535	14
28	Z. Naturfo.-A	5	0.93	83.66	0.783	0.180	15
29	Ark. Geophys.	4	0.75	84.41	-	-	-
30	Aust. J. Geophys.	4	0.75	85.16	-	-	22
31	Ind. J. Phys. -B	4	0.75	85.19	-	-	14
32	Philos. Mag.	4	0.75	86.66	-	-	17
33	Pur. Appl. Geophys.	4	0.75	87.41	0.550	0.031	12
34	Tellus	4	0.75	88.16	-	-	21
35	Act. Vet. H.	3	0.56	88.72	0.111	0.000	21
36	Ind. J. Phys.	3	0.56	89.28	-	-	14
37	Ind. J. Rad. Sp.	3	0.56	89.84	0.049	0.019	6
38	J. phys. -A	3	0.56	90.40	2.189	0.421	13
39	Nuov. Cim. -A	3	0.56	90.96	0.495	0.123	-
40	Phys. Rev. L.	3	0.56	91.52	-	-	17
41	Radio Sci.	3	0.56	92.08	0.0609	0.161	12
42	Act. Astron	2	0.37	92.45	0.141	0.016	5
43	Contemp. Phys.	2	0.37	92.82	1.541	0.111	13
44	IEEE J. El.	2	0.37	93.19	-	-	-
45	Lett. Nuov. C.	2	0.37	93.56	-	-	2
46	P.Phys. Soc. -A	2	0.37	93.93	-	-	2
47	Telecom J.	2	0.37	94.30	0.032	0.000	2
48	Act. Phys. S. I.	1	0.19	94.49	-	-	-
49	Trans. Am. Nucl. Soc.	1	0.19	94.68	-	-	-
50	Ann. Ny. Acad. Sci.	1	0.19	94.87	0.830	0.141	-
51	Ann. Phys.	1	0.19	95.06	0.375	0.131	11
52	Ark. Fvsik	1	0.19	95.25	-	-	1

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Sl. No.	Title of Journal	No. of citations	Percentage	Cumulative percentage	Impact Factor	Immediacy Index	Coverage in No. of A&I Journals
53	Astron. Z.	1	0.19	95.44	0.361	0.128	8
54	Czec. J. Phys.	1	0.19	95.63	0.309	0.141	17
55	Geophys. J. R.	1	0.19	95.82	-	-	-
56	Ind. J. Pur. Appl. Phys.	1	0.19	96.01	0.132	0.008	19
57	Icarus	1	0.19	96.20	1.916	0.425	8
58	J. Environ. Sci.	1	0.19	96.39	-	-	-
59	J. Franklin Inst.	1	0.19	96.58	0.212	0.159	-
60	J. Oper. Res.	1	0.19	96.77	-	-	31
61	J. Space Rock.	1	0.19	96.96	0.4236	0.216	14
62	JETP Letters	1	0.19	97.15	0.978	0.223	11
63	Nature Wissen.	1	0.19	97.34	0.834	0.168	31
64	Nature- Phys. Sci.	1	0.19	97.53	-	-	-
65	Nucl. Instruments	1	0.19	97.72	-	-	-
66	Operat. Res. Qua.	1	0.19	97.91	-	-	-
67	P. Ind. Acad.Sci. -A	1	0.19	98.10	0.203	0.048	-
68	P. IEEE	1	0.19	98.29	1.992	0.331	18
69	P.Phys. Soc. -B	1	0.19	98.48	-	-	-
70	P.Roy. Soc.	1	0.19	98.67	-	-	-
71	Phys. Earth Planet.	1	0.19	98.86	1.1861	1.175	12
72	Physica	1	0.19	99.05	-	-	12
73	Physica Scr.	1	0.19	99.24	0.878	0.153	14
74	Rev. Sci. Ins.	1	0.19	99.43	1.288	0.507	28
75	Z.Meteorol.	1	0.19	99.62	-	-	9
76	Book	1	0.19	99.81	-	-	-
77	Book	1	0.19	100.00	-	-	-
Total		533					

The citation frequency and cumulative citations were plotted on semi-log scale in Fig. 6 providing Bradford-Zipf citograph. Similar studies have been reported (33,43-44).

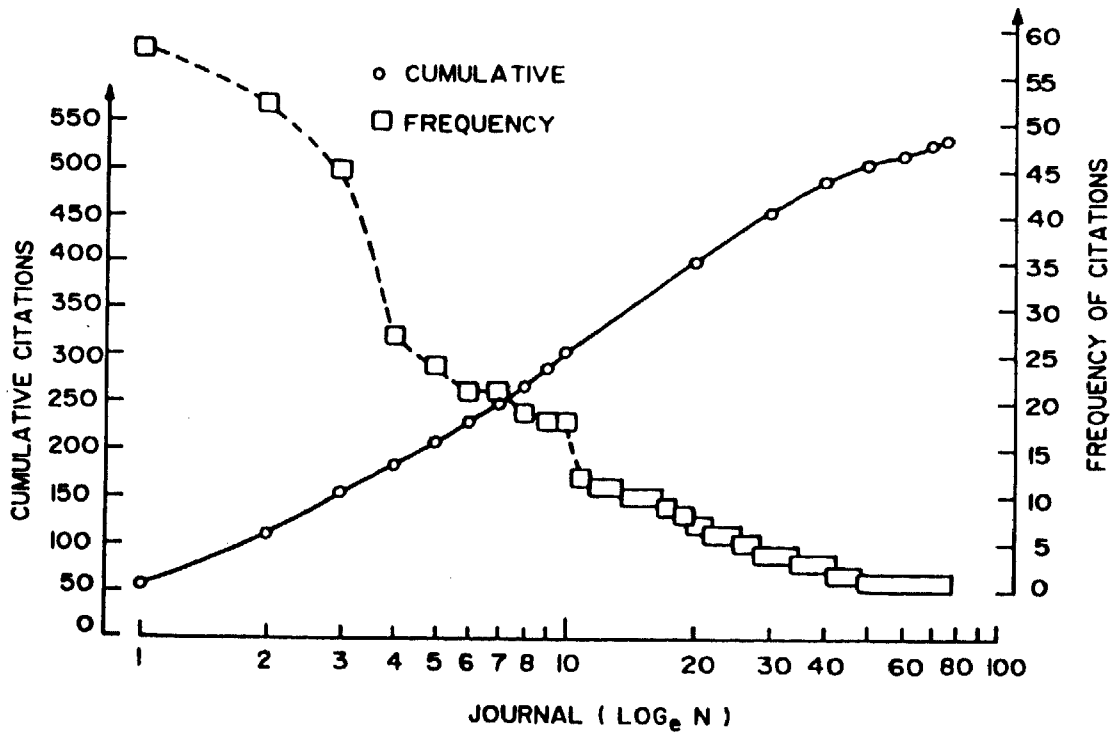


Fig. 6 Bradford-Zipf Citograph for Publications of Vikram Sarabhai

Table 6 gives the country-wise distribution of citing journals and the number of citations in them. Among the top ranking journals citing Vikram Sarabhai, 22 are from United States with 220 citations, 12 from United Kingdom with 41 citations, eight from India having 34 citations, and five from Russia having 41 citations.

Table 6. Countrywise Break up of Citing Journals

Sl. No.	Country	Citing Journals	No. of Citations	Percentage	Cumulative Percentage
1	United States	22	220	41.44	41.44
2	United Kingdom	12	41	7.73	49.17
3	India	8	34	6.40	55.57
4	Netherlands	6	76	14.31	69.88

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Sl. No.	Country	Citing Journals	No. of Citations	Percentage	Cumulative Percentage
5	Russia	5	41	7.73	77.61
6	Germany	4	8	1.50	79.11
7	Italy	4	24	4.52	83.63
8	Sweden	3	6	1.13	84.76
9	Japan	2	34	6.40	91.16
10	Switzerland	2	6	1.13	92.29
11	Australia	2	4	0.76	93.05
12	Canada	1	19	3.57	96.62
13	Czechoslovakia	1	1	0.18	96.80
14	Denmark	1	4	0.76	97.56
15	France	1	8	1.50	99.06
16	Hungary	1	3	0.57	99.63
17	Poland	1	2	0.37	100.00

Subject-wise distribution of citing journals and citations is provided in Table 7. The impact of Sarabhai's research is evident from the applications of his research in the interdisciplinary domains of Astronomy (179), Physics (152), Geophysics (120), General science (39), Geology (17), Nuclear physics (11); Domains such as Veterinary Science(3), Computers(2), Telecommunication (2), have also referred his papers thus showing extradisciplinary impact.

Table 7. Distribution of Citations and Journals According to Disciplines

Subject	No. of Citations	No. of Citing Journals
Astronomy	179	10
Physics	152	30
Geophysics	120	12
Science	39	7
Geology	17	2
Nuclear Physics	11	3
Veterinary Science	3	1
Computers	2	2

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Subject	No. of Citatlons	No. of Citing Journals
Electronics	2	1
Telecommunication	2	1
Aeronautics &Astronautics	1	1
Chemistry	1	1
Electrical Engineering	1	1
Environmental Sciences	1	1
Instrumentation	1	1
Meteorology	1	1
Total	533	75

4.8 Citation Time Lag

'Citation time-lag' is another measure that may throw light on interdependence of research programs or individual scientists. Usually, scientific papers are published before the citing paper or perhaps in the same year. That is, time-lag is positive, or zero, time-lag being the difference between the year of citing and the year of cited paper. The average value of time-lag within a particular citing paper or series of papers reflects how modern the paper is or how integrated it is in the evolving research front. In rapidly evolving 'hot' areas time-lag will be small and in many cases zero. If time-lag is large, say ten years, it usually indicates that the paper or series of papers belongs to a stagnating research area or is out of contact with main stream of research.

Time-lag between publication of an article and its receiving first citation, in the case of publications of Vikram Sarabhai is in the range of 0 to 15 years. It was revealed that 10 papers were cited in the same year of publication, but three papers were cited after 15, 11, and 10 years of their publication. To get first citation it required mean (2.45), mode (1.00), Variance (2.94), and standard deviation (1.71) in years.

5 CONCLUSION

The present citation analysis clearly reveals in quantitative terms, the impact of contributions of Vikram Sarabhai in the interdisciplinary domains such as Astronomy, Physics, Nuclear physics, Geology, Geophysics, General science, and extradisciplinary subjects like Veterinary science, Computers and Telecommunication.

The high rate of citations to his papers in journals of international scope and journals of high impact factor is a clear indication of their high quality. This confirms that his contributions received wide recognition and high visibility.

It is further suggested that a thorough study may be taken up to know the reasons for which Sarabhai's articles received citations.

6 REFERENCES

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APPENDIX-1

HIGHLY CITED PAPERS OF VIKRAM SARABHAI
(The number at the end of each entry indicates the number of citations the paper has received)

- P1. V. Sarabhai
Some consequences of Non-uniformity of solar wind velocity. *J.Geophys.Res.* 68(5),1963, 1555 .[62].
- P2. G.Subramanian and V. Sarabhai
Consequences of the distribution of galactic cosmic-ray density of the solar system. *Astrophys. J.* 149, 1969, 417. [35].
- P3. M. S.Dhanju and V.Sarabhai
Short period variations of cosmic-ray intensity. *Phys. Rev. Lett.*19(5) , 1967 ,252.[26].
- P4. V. Sarabhai and K.N. Nair
Daily variation of the geomagnetic field and the deformation of the magnetosphere. *Nature.* 223, 1969, 603.[26].
- P5. P.N.Pathak and V.Sarabhai
A study of the long term modulation of galactic cosmic-ray intensity. *Planet.Space.Sci.* 18, 1970, 81.[26].
- P6. V. Sarabhai and G.Subramanian
Galactic cosmic-rays in solar system. *Astrophys. J.*145 , 1966, 206. [25].
- P7. V.Sarabhai and R.P. Kane
World-wide effects of continuous emission of cosmic-rays from the Sun. *Phys. Rev.* 90, 1953, 204.[23]
- P8. G.L. Pai and V. Sarabhai
Periodic fluctuations in the geomagnetic field during magnetic storms. *Planet. Space Sci.*12, 1964, 855. [18].
- P9. V. Sarabhai and G. Subramanian
Galactic cosmic-rays in the solar system. *Ninth International Conference on Cosmic-Rays.* 1 , 1965 , 1970. [16].
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Anisotropy of galactic cosmic rays and interplanetary magnetic field. *Nature.*206, 1965, 703. [16].