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Research Publications of Prof. C.N.R. Rao Over the Period of 20 years from 2001-2020: A Study

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The study aims to find out the publication details of Prof. C N R Rao which has been indexed under the Web of Science database over the period of 20 Years from 2001 to 2020. The methodology adopted for the present research study is scientometrics tools such as authorship pattern and collaboration, degree of collaboration, and citations. The study has revealed that a total of 371 publications contributed by Prof. CNR Rao in collaboration up to the end of the year 2009, no one publications are indexed in the web of science contributed by CNR after 2009. The highest 305 publications are articles were published in journals and a maximum of 125 publications was in three authorship patterns. He has contributed most of his (72.24%) publications in the field of chemistry. The mean value of the Degree of Collaboration is 0.97.

Key Words: *Scientometrics, C N R Rao, Chemistry, Physics, Material Science, Science and Technology.*

1 INTRODUCTION

Publication productivity is the measure of the relationship between the output of research and inputs. Evaluating the productivity of a research highlights the contribution of the institution and the individual scientist engaged in research. A well-known productivity indicator is the number of publications produced by scientists, institutions, or research groups. Scientometric and

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Bibliometric techniques have become tools to evaluate the research productivity of individual and institutes.

Scientometrics

Scientometrics and Bibliometrics are a set of methods for measuring the production and dissemination of scientific knowledge. Derek de S. P and Nalimov V.V were the originators of the discipline.

Scientometrics is the study of 'Science of Science'. It is the study of measuring and analysing the science, technology and innovation of major research issues. It includes the measurement of impact, reference sets of articles to investigate the impact of journals and institutes. Scientometrics has typically been defined as the "quantitative study of science and technology". In other words, scientometric is concerned with the quantitative features and characteristics of science and scientific research. Emphasis is placed on investigations in which the development and mechanism of science are studied by statistical and mathematical methods.

Bibliometrics

Bibliometrics is statistical analysis of written publications, such as books or articles Bibliometric methods are frequently used in the field of library and information science. . Bibliometrics is a set of methods for quantitative analysis of scientific publications. It is based on number of publications and number of citations, and these are used for the analyses. H-index and Impact Factors are two examples of indicators. The number of publications used as a measure of scientific productivity and the number of citations as a measure of scientific impact.

About C.N.R. Rao:

Chintamani Nagesa Ramachandra Rao popularly known as C. N. R. Rao, is an Indian chemist who has worked mainly in solid-state and structural chemistry in various institutions / universities in the world. He has honorary doctorates from 83 universities from around the world. Prof CNR Rao has received the India's highest national award of "Bharat Ratna" in the year 2014. He is familiar as a world-leading chemist from India and he has contributed more than 2000 scientific research publications and many books.

2 REVIEW OF LITERATURE

Review of literature is a secondary source and it is an important component for any research work. It provides the current knowledge, including substantive findings, as well as theoretical and methodological contributions to a particular topic. Balutagi, Huded and Devi have studied the measuring research contributions of Prof. Anurag Kumar. It reveals that a total of 181 publications

contributed during his 36 years of experience. He has published a majority of 171 (94.48%) publications in collaboration with others. He has produced the highest 45.9% of publications in the field of computer. Gadad and Ravi[1] have studied the publications productivity of Prof. C.N.R. Rao during 1956-1975 by using Web of Science indexed database. The study highlighted that a total of 226 publications were published during the study period and the highest 20 (8.85%) publications were published in the year 1975, in which a maximum of 88 papers are authored by three authorships, the highest number of papers were published in the Canadian journal chemistry, and highest 74 papers are published in physical chemistry domain, and also it has received highest citations.

3 METHODOLOGY

The methodology adopted for the present research study is scientometrics. The researcher has used scientometrics tool to analyse the research activities of the particular field, author, institutions and journals. Scientometrics is the study of measuring and analysing science, technology and innovation. Research issues include; the measurement of impact, reference sets of articles to investigate the impact of journals and institutes, understanding of scientific citations, mapping scientific field and the production of indicators for use in policy and management contexts [1].

The present research study intended to examine the publications contributions of Prof. C.N.R. Rao indexed in the Web of Science Over the period of 20 years i.e. from 2001 to 2020. The study measured by annual publications, sources of publications, access of databases and type of documents contributed by Prof. C.N.R. Rao.

Web of Science

The researcher has used web of science database platform to study Prof. C.N.R. Rao's research publication. Web of Science is formerly known as Thomson Reuters Web of Knowledge. It is a citation index database, containing core journal articles, conference proceedings, data sets, and other resources in the sciences., medical sciences, dental sciences, social sciences, arts, and humanities. Web of science platform provide access to multidisciplinary and regional citation indexes, specialist subject indexes, a patent family index and an index to scientific data sets. It provides a common search language, navigation environment, and data structure allowing researchers to search broadly across particular field. The Web of Science Core Collection serves as the standard data set underpinning the journal impact metrics found in the Journal Citation Reports and the institutional performance metrics found in Incites.

4 OBJECTIVES OF THE STUDY

1. To study the Chronological Distribution of publications of Prof. C.N.R. Rao
2. To study the Authorship Pattern of Publications of Prof. C.N.R. Rao
3. To study the Degree of Collaborations of Prof. CNR. Rao's publications
4. To study the type of Documents contributed by Prof. C.N. Rao during 2001-2020

5 DATA ANALYSIS

The study analysed year wise contribution of publications of prof. C.N.R. Rao for a period of 20 years form 2001-2020 as reflected in the Web of Science database. A total of 371 research documents were retrieved from the Web of Science database which was exported to MS-Excel for further tabulation. Based on the total publications, this study investigated the growth of year wise contributions of publications, sources of publications, type of documents, sources of databases, etc.

Chronological Distribution of publications of Prof. C.N.R. Rao

A total of 371 research documents were retrieved from the Web of Science database contributed by Prof. C.N.R. Rao from 2001 to 2009. There are no documents indexed in the web of science from 2010 to 2020 contributed by Prof. C.N.R. Rao the same is presented in Table 1. The table also presents year wise cumulative total publications and year wise cumulative percentage of publications

Table 1: Chronological Distribution of publications of Prof. C.N.R. Rao's

Year	TP	CTP	% TP	% of CTP
2001	51	51	13.75	13.75
2002	48	99	12.94	26.69
2003	47	146	12.67	39.36
2004	46	192	12.40	51.76
2005	38	230	10.24	62.00
2006	41	271	11.05	73.05
2007	43	314	11.59	84.64
2008	43	357	11.59	96.23
2009	14	371	3.77	100.00

2010	0	371	0.00	100.00
2011	0	371	0.00	100.00
2012	0	371	0.00	100.00
2013	0	371	0.00	100.00
2014	0	371	0.00	100.00
2015	0	371	0.00	100.00
2016	0	371	0.00	100.00
2017	0	371	0.00	100.00
2018	0	371	0.00	100.00
2019	0	371	0.00	100.00
2020	0	371	0.00	100.00
Total	**371**		**100**	

The table demonstrates that there are 371 publications published by Prof. C.N.R. Rao during 2001 to 2009. The highest of number of publications contributed in the year 2001 representing 13.75 % of total publications followed by 48 (12.94%) publications in the year 2002 and this number gradually decreased from year to year taking the number to 14 in the year 2009 representing 3.77% of the total publications. The year 2010 onwards nothing indexed in the Web of science database contributed by Prof. C.N.R. Rao. The cumulative percentage shows that nearly 52% of the total publications have been published in the first 4 years and the remaining 48 % publications during the next 5 years.

Domain-wise contributions

Prof. C.N.R. Rao has contributed his research publications in the following 13 domains. Chemistry (72.24%), Physics (42.05%), Material Science (32.08%), Science and Technology (13.48%), rest of area of research is below 1% of publications. The same has been shown in table no. 2.

Table 2: Area of Research by C.N.R. Rao

Sl. No.	Research Area	No. of Publ.	% of Publ
1	Chemistry	268	72.24
2	Physics	156	42.05
3	Materials Science	119	32.08

4	Science Technology Other Topics	50	13.48
5	Crystallography	3	0.81
6	Metallurgy Metallurgical Engineering	3	0.81
7	Engineering	2	0.54
8	Business Economics	1	0.27
9	Electrochemistry	1	0.27
10	Instruments Instrumentation	1	0.27
11	Optics	1	0.27
12	Public Administration	1	0.27
13	Spectroscopy	1	0.27

Type documents published by Prof. C.N.R. Rao

There are different forms of documents in the scientists communicating their research findings. Prof. C.N.R. Rao scientist is not an exception with publishing a variety of documents during the study period. Total 371 publications were published by Prof. C.N.R. Rao during the study period and these publications have been classified based on the type of documents and the same has been shown in Table 3.

Table 3: Type of Documents

Sl. No.	Type of Documents	No. of Documents	%
1	Articles/ Scientific Papers	305	82.21
2	Proceedings Papers	23	6.20
3	Review Articles	19	5.12
4	Editorial Materials	10	2.70
5	Biographical-Items	7	1.89
6	Corrections	4	1.08
7	Letters	2	0.54
8	Meeting Abstracts	1	0.27
Total		**371**	**100.00**

It is observed that entire 371 publications contributed by C.N.R. Rao are in various types of documents during the study period and indexed in the Web of Science database, of which the articles published in journals with the huge number of 305 out of 371 publications have dominance over all other types taking the lion's share of 82.21%. It is followed by 23(6.20%) of documents published in proceedings papers, 19 (5.12%) are Review Articles, 10 (2.70%) are Editorial Materials, and the rest of 14 (3.78%) documents are shared in various publications with single digit, such as biographical items (7), Corrections (4), Letters (2) and Meeting Abstracts (1).

Authorship Pattern and Collaborative Research

The study of the Authorship pattern or production is one of the significant aspects of the scientometrics analysis. Due to the interdisciplinary nature of the subject, the universe of knowledge is ever dynamic and is ever-growing. More and more specializations in the subjects have emerged as a result of increased participation of a group of researchers of different expertise. The productivity of authors in the context of research and development is normally measured in terms of his/her scientific and technical research output. To analyze the authorship patterns of Prof. C.N.R. Rao's publications, the data was collected from the Web of Science database over the period of 20 years (2001-2020) and presented in table 4 as given below.

Table 4: Authorship Pattern of Publications

Sl. No.	Authorship Pattern	No. of Articles	No. of Authors	% of Articles	% of Authors
1	Single Author	10	10	2.70	0.72
2	Two Authors	63	126	16.98	9.13
3	Three Authors	125	375	33.69	27.17
4	Four Authors	78	312	21.02	22.61
5	Five Authors	54	270	14.56	19.57
6	Six Authors	20	120	5.39	8.70
7	Seven Authors	12	84	3.23	6.09
8	Eight Authors	3	24	0.81	1.74

9	Nine Authors	4	36	1.08	2.61
10	Ten Authors	1	10	0.27	0.72
13	Thirteen Authors	1	13	0.27	0.94
Total		**371**	**1380**	**100.00**	**100.00**

The above table depicts the authorship pattern of Prof. C.N.R. Rao 1380 authors have contributed to a total of 371 publications in collaboration with Prof. C.N.R. Rao. The table also exhibits the number of sole authors, joint authors and the number of multiple authors. Prof. C.N.R. Rao has contributed 10 (2.70%) publications without any collaboration during this study period. The remaining 361 (97.3%) publications are in collaboration with others. The highest number 125 (33.69%) publications collaborated with three authors followed by 78 (21.02%) collaborated with four authors, 63 publications with two authors representing 16.98% of the total publications, 54 (14.56%) publications collaborated with five authors, 20 (5.39%) publications collaborated with six authorship, 12 (3.23%) publications collaborated with seven authors. The rest of 2.42% of publications are shared in single-digit and published in collaboration with eight, nine, ten, and thirteen authors respectively.

Year-wise Authorship Pattern

To identify the year-wise productivity of Prof. C.N.R. Rao's collaboration publications, the data collected from the Web of Science database has been analyzed and presented in table 5 given below.

Table- 5: Year-wise Distribution of Research Productivity of Prof. C.N.R. Rao's

Year	1	2	3	4	5	6	7	8	9	10	13	Total
2001	4	5	18	10	11	1	3					**52**
2002		9	19	10	7	3						**48**
2003	2	9	20	7	5	2	1		1			**47**
2004	3	4	16	11	8	3						**45**
2005		10	5	11	6	4		2				**38**
2006		9	13	8	3	2	3	1		1	1	**41**
2007		6	18	8	5	3	2		1			**43**
2008		9	14	8	7	2	2		1			**43**
2009	1	2	2	5	2		1		1			**14**
Total	**10**	**63**	**125**	**78**	**54**	**20**	**12**	**3**	**4**	**1**	**1**	**371**

(Note: 1,2,3.....13 Authorship Pattern)

The table depicts that the collaboration of research by joint researchers and multiple researchers particularly from 2 to 6 researchers' team is linear and steady. The highest 125 publications were published by three authorship patterns, followed by 78 publications by four authorship. Two articles contain the highest number of author's i.e. ten and thirteen respectively.

Degree of Collaboration

The degree of collaboration is defined as the ratio of the number of collaborative research papers published and a total number of papers published in the discipline during a certain time. The formula suggested by Subramanya (1983) is used in this study is as under.

$$DC = \frac{Nm}{Nm + Ns}$$

Where, DC= Degree of Collaboration in a discipline
Nm= Number of multi authored papers in a discipline
Ns= Number of single-authored papers

To know the year-wise Degree of Collaboration of Prof. C.N.R.Rao's publications published during 2001 to 2009 the data collected from the Web of Science database has been analyzed and presented in the table given below.

Table 6 : Degree of Collaborations of Prof. CNR. Rao's publications

Year	Single Author Publ.	Multi Authors Publ	Total Publ.	DC
2001	4	48	52	0.92
2002	0	48	48	1.00
2003	2	45	47	0.96
2004	3	42	45	0.93
2005	0	38	38	1.00
2006	0	41	41	1.00
2007	0	43	43	1.00
2008	0	44	44	1.00
2009	1	12	13	0.92
Total	**10**	**361**	**371**	**0.97**

The table reveals that the value of the degree of collaboration is increased from 0.92 in the year 2001 to 1.00 in the year 2002. Again, it has decreased to 0.96 and 0.93 in the years 2003 and 2004 respectively. However, it has increased to 1.00 in the year 2005 and it maintains same up to 2008, again it is decreased to 0.92 in the year 2009. The mean value of the Degree of Collaboration is 0.97 over the study period. Even though there are fluctuations in the degree of collaboration during the study period, a progressive increase in the degree of collaboration in subsequent years is be observed.

Citations of Prof. C.N.R. Rao Publications

The productive authorship is considered based on the impact measured as the number of citations received by the publications of a given author. The number of average citations per paper (ACPP) is also considered as a good indicator for quality of publications.

Table 7: Citations of Prof. C.N.R. Rao's Publications

Year	TP	% TP	TC	ACPP
2001	51	13.75	63	1.24
2002	48	12.94	323	6.73
2003	47	12.67	604	12.85
2004	46	12.40	831	18.07
2005	38	10.24	1220	32.11
2006	41	11.05	1239	30.22
2007	43	11.59	1441	33.51
2008	43	11.59	1812	42.14
2009	14	3.77	2119	151.36
Total	**371**	**100**	**9652**	**∑36.47**

The table depicts that year-wise citation received by Prof. C.N.R. Rao's publications. A total of 371 publications received a total of 9562 citations from 2001 to 2009; an average per citation per paper is 36.47. A total14 publications were the highest 2119 citations received in the year 2009, followed by 43 publications were received 1812 citations with an average per paper is 42.14. The highest number of 51 papers were published in the year 2001, received the lowest 1.24% average citation per paper.

6 CONCLUSION

Prof. C.N.R. Rao is one of the renewed exponents in the materials science field. He has amazing and wide-ranging contributions to the world along with his research team. The domain has reached the most crucial stage in chemistry. He has published 371 publications during the study period, the highest 51 publications published in the year 2001 and the lowest 14 publications in 2009. He has contributed 10 (2.70%) publications as a single author, and the rest of 361 (97.3%) publications were in collaboration with 1370 co-authors. Thus, this study attempt helps the researchers to know about Prof. CNR Rao's research publications.

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