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Vivekanandhan S Dr

*SRM Institute of Science and Technology, Kancheepuram Dist*, vivek.nandhan@gmail.com

Rajendran Periyasamy Dr

*RM Institute of Science and Technology, Kancheepuram Dist*, periyaswamyrajendran@gmail.com

Sivasamy K Dr

*Thiru A Govindhasamy Govt. Arts College, Tindivanam, Villupuram Dist*, mksiva@yahoo.com

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# Scientometric analysis of pollution control research publications in Indian from SCOPUS database between 2007 and 2018

\*Dr. S Vivekanandhan, \*\*Dr. P. Rajendran and \*\*\*Dr. K Sivasamy

\*Assistant Librarian, SRM Institute of Science and Technology, Kattankulathur, Kancheepuram Dist.  
Mail: [vivek.nandhan@gmail.com](mailto:vivek.nandhan@gmail.com)

\*\*Unverswity Librarian, SRM Institute of Science and Technology, Kattankulathur, Kancheepuram Dist.  
Mail: [periyaswamyrajendran@gmail.com](mailto:periyaswamyrajendran@gmail.com)

\*\*\*College Librarian, Thiru A Govindhasamy Govt. Arts College, Tindivanam, Villupuram Dist.  
Mail: [mksiva@yahoo.com](mailto:mksiva@yahoo.com)

## Abstract

This paper aims to analyze the pollution control research publications by the Indian contributions from the scopus online database between 2007 and 2018 with 33084 research publications. Out of that, 1997 publications are contributed by India. This study examine the year wise growth of research publications, relative growth rate and doubling time, bibliographic form of publications, top 10 country wise contributions and authorship pattern. During the study period, maximum of 226(0.68%) publications are contributed in the year 2018. Activity index ranges between 79.89 and 121.86 during the study period. The relative growth rate is found that, 0.61 to 0.12 between 2007 and 2018. On the same time doubling time values are 1.14 to 5.77. During the study maximum of 1441 (72.16%) publications is article. 607 Indian authors research publications are collaborated by 69 other countries. Maximum of 112(5.61%) publications are collaborated by United States. The average degree of collaboration is 0.92, average collaborative coefficient is 0.61 and average collaborative index is 0.30. During the study period it is identified that, CAI for single, two and three authorship are decreasing trend.

Keyword: Bibliometrics, relative growth rate and doubling time, degree of collaboration and co-authorship index.

## Introduction

Human activity produced a marvelous amount of waste resources. The waste materials are discharged in various components of the surroundings in which they bring about unwanted changes. The phenomenon is termed as environmental pollution which has been defined as an unwanted change in physical, chemical or biological characteristics of air, land and water will be or may be harmful to human being and other life, industrial process, living conditions and cultural assets or cause wastage of our raw material resources.<sup>1</sup> Most pollution from human activities are happen in or near by urban and industrial areas where pollution sources such as cars, bike, bus, larry and factories are concentrated. Industrialized agriculture is also one of the most important sources of pollution. Some pollutants contaminate the air as they are created, some others are carried by wind or flowing water into other region.<sup>2</sup>

## SCIENTOMETRICS: AN OVERVIEW

Scientometrics is an important field of information science because it presents a unique set of techniques for evaluation, analysis and monitoring the information resources and for the management of knowledge. Scientometric studies are conducted in order to assess the quantitative and qualitative development of subject field especially in sciences and technology. The research and development efforts in the field of pollution control research have brought out wonderful publications. Therefore, scientometric study is need to conducting in the field of pollution control research to assess the qualitative and quantitative developments in this field of knowledge. The first scientometrics model of scientific growth was suggested by Price (1963)<sup>3</sup>.

The study of scientific research publications has a long history of back dating to the early decades of the past century. However, even though the quantity of research publications in this area it was not until 1969 that the term bibliometrics was first appeared in print (**Pritchard,1969**)<sup>4</sup>. It was defined as the “application of mathematical and statistical methods to books and other media of communication” and the term was quickly adopted and used, particularly in North America (**Wilson,1999**)<sup>5</sup>. At the same time, **Nalimov and Mulchenko**(1969)<sup>6</sup> coined the term scientometrics to refer to “Scientometrics as the quantitative methods of dealing with the analysis of scientific literature with scientific point of view”. In disparity, this term was broadly used in Europe (**Wolfram,2003**)<sup>7</sup>.

**Tague-Sutcliffe (1992)**<sup>8</sup> defined as “scientometrics is a study of quantitative aspects of scientific publications or economic activity”. In the beginning, scientometrics was restricted to measurement of science communication, whereas bibliometrics was designed to deal with more common information processes. In the recent era, scientometrics and bibliometrics are used by synonyms (**Glanzel,2003**)<sup>9</sup>.

### Review of Literature

**Mohanathan P and Rajendran N (2018)**<sup>10</sup> examined their study on scientometric analysis of research output in India in Greenhouse Effect during the period of 2001 to 2017 from SCOPUS Database with 568 publications. The study revealed that year wise growth, international affiliations, relative growth rate, doubling time and contributions of authors were analyzed. Maximum of 395 (69.54%) publications are articles and maximum of 60 (31.91%) Indian publications are collaborated by United States of America (USA).

**Vellaichamy A and Jeysankar R (2015)**<sup>11</sup> analyzed 14052 contributions on myeloma research publications from 2008 to 2012 in the SCOPUS database. The study identified growth rate, authorship pattern, subject-wise distribution of articles, country wise, language wise and institutions-wise contributions and also prolific authors have been analyzed. Out of 14052 contributions, only 12.97% are single authored publications and 87.03% are multi authored publications. The average degree of collaboration was 0.87. Maximum of the authors from the world have a preference to publish their research publications on the journal of Blood (3.88%).

**Siva N, Vivekanandhan S and Manickaraj J (2018)**<sup>12</sup> have analyzed about digital library research publications which are indexed in SCOPUS database between 2008 and 2017 with 10345 publications. The study identified the year wise growth publications, top 10 authors, institution and country as well as

the type of publication, authorship pattern and citation range. Further analyzed the average degree of collaboration was 0.78, the relative growth rate was decreasing trend and doubling time was increasing trend. The United States ranked first with 2650 (25.62%) publications and Giles C.L. stands with highest of 59 (0.57%) publications.

### **Objectives**

- To identify the year wise growth of pollution control research publications
- To analysis relative growth rate and doubling time
- To identify the bibliographic form of publications
- To identify the top 10 country wise contributions
- To analysis the authorship pattern and collaborative measures
- To identify the Co-Authorship Index (CAI)

### **Limitations**

This study confined that, only the pollution control research publications in India for twelve years from 2007 to 2018 indexed in the SCOPUS database. The search was conducted with the following search strategy: ((TITLE-ABS-KEY ("Pollution Control") AND AFFILCOUNTRY ("India")) AND PUBYEAR > 2006 AND PUBYEAR < 2019). The present study considers for few scientometric techniques to analysis the research work.

### **Methodology**

Bibliographic records related to the pollution control research publications in India were extracted from the SCOPUS multidisciplinary online database, and has been classified using MS Excel for the purpose of analysis. Further some statistical tools such as percentage analysis, frequency distribution and few scientometric techniques such as relative growth rate and doubling time, degree of collaboration, collaborative measures were used for the study.

### **Analysis and Interpretation**

#### **Year wise Growth of Publication and Activity Index**

During the study period from table 1, it is identified that 33084 research publications are contributed by world. Out of that, 1997 publications are contributed by India. From the India contributions, maximum of 226(0.68%) research publications are contributed in the year 2018, followed by 206 (0.62%) publications in the year 2017. Minimum of 94(0.28%) publications are in the year 2008. Activity Index (AI) has been calculated and compare to India and World research performance in the field of pollution control research publications.

This study identified from table 1, the activity index ranges between 79.89 and 121.86 during the 12 years study period and it has been fluctuation trend. From the year 2007- 2009 and 2017 the activity index is lower than the world average. From the year 2010, 2012 to 2018 expect 2017 the activity index is higher than the world average of 100.

**Table - 1 Year wise Growth of Publication and Activity Index**

Year	World Publications	%	Indian Publications	Share of Indian Publications	Activity Index (AI)
2007	2276	6.88	112	0.34	81.52
2008	1876	5.67	94	0.28	83.01
2009	2219	6.71	107	0.32	79.89
2010	2665	8.06	167	0.50	103.81
2011	3783	11.43	183	0.55	80.14
2012	2603	7.87	175	0.53	111.38
2013	2406	7.27	149	0.45	102.60
2014	2561	7.74	185	0.56	119.67
2015	2719	8.22	200	0.60	121.86
2016	2863	8.65	193	0.58	111.68
2017	3447	10.42	206	0.62	99.01
2018	3666	11.08	226	0.68	102.13
<b>Total</b>	<b>33084</b>	<b>100.00</b>	<b>1997</b>	<b>6.04</b>	<b>100.00</b>

### Relative Growth Rate and Doubling Time

The growth of publications were analysed by using two parameters like Relative Growth rate and Doubling time (Mahapatra 1985)<sup>13</sup>. RGR is a measure to study the increase in number of articles of time. It is calculated as

$$R(a) = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

R(a) = RGR = the mean relative growth rate over the specific period of interval

W<sub>1</sub> = the logarithm of beginning number of publications/pages

W<sub>2</sub> = the logarithm of ending number of publications/pages after a specific period of interval

T<sub>2</sub> – T<sub>1</sub> = the unit difference between the beginning time and the ending time.

The relative growth rate and the doubling time (Dt) was calculated and the result are represented in table 2. The Dt is directly related to RGR. In the time required for articles to become double of the existing amount. The corresponding doubling time for each specific period of interval can be calculated by the following formula,

$$Dt = \frac{0.693}{R(a)}$$

The Table 2 signifies the chronological distribution of relative growth rate and doubling time in the field of pollution control research publications in India during the period of 2007-2018. Doubling time has been calculated by directly from the growth rate. The relative growth rate is found that maximum of 0.61 in the year 2008 and minimum of 0.12 in the year 2017 and 2018. This study identified that, RGR is decreasing trend. On the same time doubling time values are 1.14 in the year 2008 and 5.77 in the year 2018 and it is identified increasing trend from 2007 to 2018.

**Table - 2 Relative Growth Rate and Doubling Time**

Year	Indian Publications	Cum.	W <sub>1</sub>	W <sub>2</sub>	RGR= (W <sub>2</sub> -W <sub>1</sub> )	Dt =0.693/RGR
2007	112	112		4.718	0.00	0
2008	94	206	4.718	5.328	0.61	1.14
2009	107	313	5.328	5.746	0.42	1.66
2010	167	480	5.746	6.174	0.43	1.62
2011	183	663	6.174	6.497	0.32	2.15
2012	175	838	6.497	6.731	0.23	2.96
2013	149	987	6.731	6.895	0.16	4.24
2014	185	1172	6.895	7.066	0.17	4.03
2015	200	1372	7.066	7.224	0.16	4.4
2016	193	1565	7.224	7.356	0.13	5.27
2017	206	1771	7.356	7.479	0.12	5.60
2018	226	1997	7.479	7.599	0.12	5.77
<b>Total</b>	<b>1997</b>					

**Table 3 Bibliographic form of Publications**

S. No	Bibliographic Form	Publications	%	Cum.	%
1	Article	1441	72.16	1441	72.16
2	Conference Paper	290	14.52	1731	86.68
3	Review	144	7.21	1875	93.89
4	Book Chapter	76	3.81	1951	97.70
5	Editorial	14	0.70	1965	98.40
6	Book	12	0.60	1977	99.00
7	Letter	5	0.25	1982	99.25
8	Note	5	0.25	1987	99.50
9	Erratum	1	0.05	1988	99.55
10	Short Survey	1	0.05	1989	99.60
11	Retracted	1	0.05	1990	99.65
12	Undefined	7	0.35	1997	100.00
<b>Total Publications</b>		<b>1997</b>	<b>100.00</b>		

Table 3 identified the bibliographic form of pollution control research publications in India from scopus database. During the study period maximum numbers of 1441 (72.16%) publications are articles, followed by 290(14.52%) conference papers, 144(7.21%) reviews, 76(3.81%) book chapters. From this study it is conformed that, top four category of publications are contributed 97.7%. Remaining 2.3% of publications are other category of publications like editorial, book, letter etc.

**Table 4 Indian author's collaborated countries**

<b>S. No</b>	<b>Country</b>	<b>Publications</b>	<b>% of 1997 Publications</b>
1	United States	112	5.61
2	South Korea	41	2.05
3	United Kingdom	41	2.05
4	China	38	1.90
5	Canada	27	1.35
6	Germany	27	1.35
7	Australia	26	1.30
8	Japan	24	1.20
9	Portugal	18	0.90
10	South Africa	17	0.85
11	Malaysia	12	0.60
12	Singapore	12	0.60
13	Italy	11	0.55
14	Netherlands	11	0.55
15	Denmark	10	0.50
16	France	10	0.50
17	Saudi Arabia	10	0.50
18	Spain	9	0.45
19	Austria	8	0.40
20	Russian Federation	8	0.40
21	Other 49 Countries	135	6.76
<b>Total Publications</b>		<b>607</b>	<b>30.40</b>

Table 4 identified that Indian authors are collaborated countries in pollution control research publications. During the study period out of 1997 Indian authors research publications, 607 publications are collaborated by 69 countries. Out of 69 countries, maximum of 112(5.61%) publications are collaborated by United States, followed by South Korea and United Kingdom with 41(2.05%) publications. Third place collaborating country is China with 38(1.90%) publications.

#### **Authorship Pattern**

During the study period, table 5 identified authorship pattern in pollution control research publications by the Indian authors. This study identified that maximum of 605(30.28%) publications are collaborated by two authors, followed by 477(23.87% publications are three authors, 350(17.52%) publications are collaborated by four authors. Out of 1997 research publications, only 167(8.36%) publications are contributed by single authors. The overall study identified that, maximum of 91.64% Of publications are multi author publications.

**Table 5 Authorship Pattern**

S. No	Authorship Pattern	Publications	%	cum.	%
1	Single Author	167	8.36	167	8.36
2	Two Author	605	30.28	772	38.66
3	Three Author	477	23.87	1249	62.54
4	Four Author	350	17.52	1599	80.07
5	Five Author	180	9.01	1779	89.08
6	Six Author	85	4.25	1864	93.34
7	Seven Author	62	3.10	1926	96.44
8	Eight Author	23	1.15	1949	97.60
9	Nine Author	22	1.10	1971	98.70
10	>9 Authors	26	1.30	1997	100.00
<b>Total Publications</b>		<b>1997</b>	<b>100</b>		

**Collaborative Measures**

**Degree of Collaboration (DC)**

Degree of collaboration denotes that the concentrations of single authored publications are relation to the multi-authored publications, suggested by **Subramanyam (1983)**<sup>14</sup>

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

Where,

DC - Degree of collaboration in a subject

Nm - Number of multiple authored publications,

Ns - Number of single authored publication

**Collaborative Coefficient (CC)**

The pattern of co-authorship collaboration among the authors can be measured with the following formula suggested by **Ajiferuke, et al. (1988)**<sup>15</sup>

$$CC = 1 - \left[ \sum_{j=0}^k \left( \frac{1}{j} \right) \times F_j / N \right]$$

where as,

F<sub>j</sub> = Number of publications with j author papers

N = Total number of the research publications and

k = the greatest number of authors/ paper in the given field.

**Collaborative Index (CI)**

The simple indicator are presently employed in the publications to the collaboration index, which is to be understand nearly as the mean number of authors per paper are suggested by **Ajiferuke, et al.(1988)**<sup>15</sup>

$$CI = \frac{\sum_{j=1}^k jf_j}{N}$$



Here

J - The number of co-authored papers appearing in a discipline

N - The total number of publications in the field over the same time period of interval and

k - The highest number of authors per paper in a same time field.

**Table 6 Collaborative Measures**

Year	1	2	3	4	5	6	7	8	9	10	Total	DC	CC	CI
2007	14	41	23	18	10	4	0	1	1	0	112	0.88	0.56	0.34
2008	10	26	28	15	9	1	2	0	0	3	94	0.89	0.59	0.31
2009	13	35	29	21	6	1	1	0	1	0	107	0.88	0.56	0.35
2010	20	50	41	34	9	6	2	1	1	3	167	0.88	0.58	0.32
2011	18	70	48	22	18	4	3	0	0	0	183	0.90	0.57	0.35
2012	18	48	47	33	12	6	8	2	1	0	175	0.90	0.60	0.31
2013	6	41	38	32	11	7	8	3	2	1	149	0.96	0.65	0.28
2014	11	59	42	36	14	6	4	4	3	6	185	0.94	0.63	0.28
2015	22	57	35	33	23	14	11	2	2	1	200	0.89	0.60	0.29
2016	8	72	40	27	27	11	4	2	1	1	193	0.96	0.63	0.30
2017	13	53	57	35	19	12	7	2	4	4	206	0.94	0.64	0.28
2018	14	53	49	44	22	13	12	6	6	7	226	0.94	0.65	0.25
<b>Total</b>	<b>167</b>	<b>605</b>	<b>477</b>	<b>350</b>	<b>180</b>	<b>85</b>	<b>62</b>	<b>23</b>	<b>22</b>	<b>26</b>	<b>1997</b>	<b>0.92</b>	<b>0.61</b>	<b>0.30</b>

Collaborative measures are identified in the field of pollution control research publications in India and to analyze degree of collaboration, collaborative coefficient and collaborative index. From the table 6 degree of collaboration is identified that 0.88 to 0.96 between 2007 and 2018. The average degree of collaboration is 0.92. Collaborative coefficient values are identified that 0.56 in the year 2007 and 2009 to 0.65 in the year 2013 and 2018. Average collaborative coefficient value is 0.61. Collaborative index values are identified that 0.35 to 0.25 between the study period of 2007 and 2018. Average collaborative index value is 0.30.

### Co-Authorship Index (CAI)

To study how the pattern of co-authorship and the use of co-authorship index suggested by **Garg and Padhi (2001)**<sup>16</sup> has been explained the under mentioned formula.

$$CAI = \left[ \frac{(N_{ij}/N_{io})}{(N_{oj}/N_{oo})} \right] \times 100$$

Where as

N<sub>ij</sub> : Number of publications having j authors in i block

N<sub>io</sub> : Total publications of i block

N<sub>oj</sub> : Number of publications having j authors for all blocks

Noo : Total number of publications for all authors and the all blocks

Here CAI = 100 implies that a country's co-authorship effort for a particular authorship correspond to the world average

CAI>100 reflects higher than average co-authorship effort

CAI<100 reflects lower than average co-authorship effort by that country for a given type of authorship pattern.

**Table 7 Co-Authorship Index**

Year	Single Authors	CAI	Two Authors	CAI	Three Authors	CAI	>3 Authors	CAI	Total
2007-2010	57	142.00	152	104.53	121	105.54	150	83.43	480
2011-2014	53	91.59	218	103.99	175	105.87	246	94.91	692
2015-2018	57	82.62	235	94.02	181	91.85	352	113.91	825
<b>Total</b>	<b>167</b>	<b>100.00</b>	<b>605</b>	<b>100.00</b>	<b>477</b>	<b>100.00</b>	<b>748</b>	<b>100.00</b>	<b>1997</b>

Co-authorship index values are calculated by using the block year wise study period of three block years in the field of pollution control research publications in India. From the table 7 it is identified that CAI for single authorship is 142 in the 1<sup>st</sup> block year of 2007-2010, 91.59 in the block year 2011-2014 and 82.62 in the block year 2015-2018. Similarly two authors CAI is 104.53 by 1<sup>st</sup> block year, 103.99 by 2<sup>nd</sup> block year and 94.02 by 3<sup>rd</sup> block year. CAI for three authors is 105.54 for 1<sup>st</sup> block year, 105.87 for 2<sup>nd</sup> block year and 91.85 for 3<sup>rd</sup> block year. CAI for more than 3 authors are 83.43 for 1<sup>st</sup> block year, 94.91 for 2<sup>nd</sup> block year and 113.91 for 3<sup>rd</sup> block year. During the study period, it is identified that CAI for single, two, three authors are decreasing trend and CAI for more than three authors is increasing trend.

### Major Findings

- During the study period, it is identified that 33084 research publications are contributed by world. Out of that, 1997 publications are contributed by India. From India's contributions, maximum of 226(0.68%) publications are contributed in the year 2018.
- During the year 2007- 2009 and 2017 the activity index is lower than the world average and the year 2010, 2012 to 2018 expect 2017 the activity index is higher than the world average.
- This study identified that, RGR is decreasing trend and doubling time is increasing trend from 2007 to 2018.
- Maximum of 1441 (72.16%) publications are articles and 607 publications are collaborated by 69 countries. Out of 69 countries, maximum of 112(5.61%) publications are collaborated by United States.
- Maximum of 605(30.28%) publications are collaborated by two authors. The average degree of collaboration is 0.92, average collaborative coefficient is 0.61 and average collaborative index is 0.30.

- During the study period it is identified that CAI for single, two, three authorship are decreasing trend and CAI for more than three authorship are increasing trend.

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