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Pollution Control Research Output in India from Scopus Database: A Scientometric Analysis

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Abstract The Scientometric study examines the research contribution of India towards pollution control by date indexed in Scopus database for 12 years from 2003 to 2014 using different qualitative and quantitative measures. Related relevant literature was reviewed. It has been identified that a total number of 28445 research publications were published during the above cited period. It is identified that 160 research institutions of India were responsible for placing India in the 3rd place for publishing 1551 publications and also to highlight the h-index gained by the top 15 institutions. Further, the analysis revealed the wise country publications with ranking and the share of India towards research publications with citations along with the type of documents. The impact of relative research effort analyzed through Publication Efficiency Index. The funding agencies are requested to allocate more funds to do many more research on Pollution Control for the betterment of the society.
Keywords *Scientometric; Pollution Control; Citation Analysis; Bibliometrics; Scopus*

1. Introduction

Pollution control was a term used in environmental science and management. Without pollution control, the waste products from over consumption, heating, agriculture, mining, manufacturing, transportation and other human activities, whether they accumulate or disperse, will degrade the environment [1]. Many of pollution control and environmental laws were enacted in the early 1970s to protect public health and welfare. A substance is considered as the pollutant, and the same has been perceived to have an adverse effect on human health, which has to be controlled towards developing a healthy society. Therefore, our industrial society needs the accurate quantitative risk assessment to evaluate the protection afforded by various levels of pollution control. We must also remain aware that determination of safe levels of pollutants based on risk analysis is a temporary measure until the mechanism of the damage done by the pollutant is understood [13].

Within India, Maharashtra state was the front runner to enact Water Pollution and Control Act in 1962. This was followed by passing of Comprehensive environmental Protection Bill for prevention of air pollution in 1983. Maharashtra, Gujarat, Madhya Pradesh were the first states in Indian union to have

pollution control board with attached analytical laboratories. The pollution control is an essential field of research in the contemporary world. If there is no proper strategy for pollution control, the waste products emanate from consumption, heating, agriculture, mining, manufacturing, transportation and other activities of the society will degrade the environment. However, the present pollution control techniques continue to reduce risk, but some more innovative technology oriented solutions are solicited in this field for the goodness of the society. In the present study analysis in the field of pollution control related research publications contributed in the SCOPUS database from 2003 to 2014.

2. Review of Literature

Vijayalakshmi S. and Ambuja R., (2013) [2] explains about the growth of literature, the degree of collaboration, and Relative Growth Rate and Doubling time on “Remote Sensing literature in Scopus database: A bibliometric analysis." Ritu Gupta, Kumbar B.D., and Rishi Tiwari, (2014) [3] reveals the research performance of 25 leading universities research output, citations and International collaborative papers on Ranking of Indian Universities in Social Sciences using bibliometric indicators during 2008-12. Raju N.G., (2014) [4] in his paper entitled "Ranking and Scattering of Journals in Physics: A Quantitative Study" shed a light about the International Journal of information dissemination and technology papers into bibliographic form-wise distribution, ranking and scattering of journals, the productivity, the obsolescence of literature and half-life of journals citations.

Zell, H. et al., (2010) [5] has analyzed his Air pollution researches during the period from 1955 to 2006, 26,253 items were listed through web of science database. From the study identified 124 countries in 24 different languages. Further they analyzed citation levels, most productive countries; highest number of author’s publications and his citation range, most productive subject area and journals are analyzed. Dobrot, Marina et al., (2013) [6] has examined his research Europe Union member countries air pollution per inhabitant, using a novel statistical approach I-distance method. His study measuring the air pollution per inhabitant and evaluating the measurement by ranking that the worst situation occurs in Luxembourg, Bulgaria, Ireland, Estonia, and Greece, while situation in Sweden, Portugal, Germany, Slovakia, and United Kingdom is much better with far less air pollution per inhabitant. That paper also seeks to explain the results of ranking and abilities of specific countries to scope with the environmental problems such as air pollution.

3. Objectives

a) To find out the country wise publications, share and ranking
b) To find out the year wise growth of literature using worldwide and India
c) To analyze the year wise citations
d) To find out the year wise International collaborative papers
e) To find out the country wise Indian Collaborative publications
f) Top 15 authors and institution wise contributions
g) To find out the type of documents involved in the research output
h) To analyze the publication efficiency index

4. Data Collection

A total number of 28445 literature output on pollution control is downloaded from Scopus multidisciplinary online database from 2003 to 2014 for the Scientometric analysis.

5. Methodology

The downloaded data on Pollution Control from Scopus is segregated and tabulated through MS-Excel spreadsheet.

6. Limitation

The analysis of pollution control is limited for 12 years from 2003 to 2014 based on the data indexed in Scopus Database alone.

7. Analysis of the Study

7.1. Global Publication Output, Share and Rank

Table 1: *Global Publications output, Share and rank of top 15 countries*

Sl. No.	Country	Publications Output			Publications Share			Publications Rank		
		2003-08	2009-14	2003-14	2003-08	2009-14	2003-14	2003-08	2009-14	2003-14
1	United States	3400	3046	6446	27.26	19.07	22.66	1	2	1
2	China	1210	4920	6130	9.7	30.8	21.55	2	1	2
3	India	630	921	1551	5.05	5.77	5.45	4	3	3
4	United Kingdom	799	751	1550	6.41	4.7	5.45	3	4	3
5	Germany	569	500	1069	4.56	3.13	3.76	5	8	5
6	Canada	535	544	1079	4.29	3.41	3.79	6	5	4
7	Japan	423	395	818	3.39	2.47	2.88	7	10	9
8	Italy	377	486	863	3.02	3.04	3.03	8	9	7
9	France	371	510	881	2.97	3.19	3.1	9	7	6
10	Taiwan	305	325	630	2.45	2.03	2.21	10	11	11
11	Spain	302	524	826	2.42	3.28	2.9	11	6	8
12	Australia	246	395	641	1.97	2.47	2.25	12	10	10
13	Netherlands	208	231	439	1.67	1.45	1.54	13	13	13
14	South Korea	196	322	518	1.57	2.02	1.82	14	12	12
15	Sweden	165	185	350	1.32	1.16	1.23	15	14	14
16	Others	2736	1918	4654	21.94	12.01	16.36			
Global		**12472**	**15973**	**28445**	**100**	**100**	**100**			

Table 1 shows that out of the total number of publications on pollution control, India is ranked as 3rd among the top 15 most productive countries with a global publication share of 1551(5.45%) during the study period of 2003-2014. The top 15 most productive countries in the publication of pollution controls have shown the wide difference in their global publication share between 1.23% to 22.66%. The United States is placed on the top with the most number of publications share of 6446(27.26%), followed by China with 6130(21.55%) share, India with 1551(5.45%). The countries that were ranked 4th to 11th places are Canada, Germany, France, Italy, Spain, Japan, Australia, and Taiwan with the global publication share varying from 3.79% to 2.21%. South Korea is placed in 12th ranked leaving Netherland and Sweden in 13th and 14th rank, respectively.

7.2. Year Wise Global Growth of Publications and India

Table 2 shows that, the Globalwise growth of publications on pollution controls and the share of India. The publication position of global is highest in the year 2011 with a record count of 3795(13.34%), lowest in the year was 2003 with 1810(6.36%), and the average publication was 2370(8.33%). India shared with a record count of 1551 (5.45%), out of which the highest number of publication was in the year 2011. The records count of 182(11.73%) with an annual share of 4.8%, the lowest number of publication was in the year 2003 and 2005 with 90 (5.80%) research publications. The average publication share of India was 129.3(8.33%). The year 2011 was most prolific for the highest number of publications for both Global Wise 3795(13.34%) and India 182(11.73%).

Table 2: *Year wise growth of publications in Global and Indian*

		Global		India		
S. No.	**Year**	**Pub**	**%**	**Pub.**	**%**	**Share%**
1	2003	1810	6.36	90	5.80	4.97
2	2004	2186	7.69	117	7.54	5.35
3	2005	2365	8.31	90	5.80	3.81
4	2006	2002	7.04	129	8.32	6.44
5	2007	2250	7.91	111	7.16	4.93
6	2008	1859	6.54	93	6.00	5.00
7	2009	2190	7.70	104	6.71	4.75
8	2010	2616	9.20	161	10.38	6.15
9	2011	3795	13.34	182	11.73	4.80
10	2012	2564	9.01	167	10.77	6.51
11	2013	2355	8.28	143	9.22	6.07
12	2014	2453	8.62	164	10.57	6.69
Total		**28445**	**100.00**	**1551**	**100.00**	**5.45**
Average		**2370**	**8.33**	**129**	**8.32**	

7.3. Indian Publication Output, Citation and International Collaborated Paper

Table 3 shows that India has published 1551 papers with 16565 citations in pollution control during 2003-2014. The annual growth incline from 90 papers with 889 citations in the year 2003 to 164 papers with 449 citations in the year 2014. The average publication per year was 129.3(8.33%) paper with 1380.4 citations. The cumulative growth of Indian publications output on pollution control increases from 630(40.62%) papers with 10427 citations during 2003-2008 to 921(59.38%) papers with 6138 citations during 2009-2014.

Table 3: *Indian publications output, Citation and International Collaboration Paper*

Year	Publication	Citation	ACP	ICP (%)
2003	90	889	9.88	10 (11.11)
2004	117	1900	16.24	12 (10.26)
2005	90	1518	16.87	7 (7.78)
2006	129	2467	19.12	11 (8.53)
2007	111	2259	20.35	20 (18.02)
2008	93	1394	14.99	35 (37.63)
2009	104	1976	19.00	17 (16.35)
2010	161	1172	7.28	28 (17.39)
2011	182	1134	6.23	40 21.98)

2012	167	816	4.89	43 (25.75)
2013	143	591	4.13	46 (32.17)
2014	164	449	2.74	84 (52.22)
2003-2008	630	10427	16.55	95 (15.08)
2009-2014	921	6138	6.66	258 (28.01)
2003-2014	**1551**	**16565**	**10.68**	**353(22.76)**

ACP = Average Citation per Paper, ICP=International Collaborative Paper

The average Indian publication citation on pollution control research papers impact as reflected in 10.68 during 2003-2014, which decreased from 16.55 during 2003-2008 to 6.66 during 2009-2014.

The year wise publication share of Indian-International collaborative papers during 2003-2014 was 353(22.76%) papers, which increased from 95(15.08%) papers was published during 2003 to 2008 was to 258(28.01%) papers during 2009 to 2014. At an outset the maximum collaborated papers of Indian was in the year 2014 with a count of 84(52.22%) papers and lowest in the year 2005 with a count of 7(7.78%) papers.

7.4. Top 15 Collaborating Countries and the Share of India

Table 4: *Contribution of India with top 15 collaborating countries*

Collaborating Country	India ICP			ICP Share %		
	2003-08	2009-14	2003-14	2003-08	2009-14	2003-14
United States	19	53	72	19.79	20.54	20.40
United Kingdom	7	21	28	7.29	8.14	7.93
China	3	20	23	3.13	7.75	6.52
Japan	5	16	21	5.21	6.20	5.95
South Korea	7	13	20	7.29	5.04	5.67
Germany	5	11	16	5.21	4.26	4.53
Canada	2	11	13	2.08	4.26	3.68
Australia	2	10	11	2.08	3.88	3.12
Portugal	1	9	10	1.04	3.49	2.83
France	5	4	9	5.21	1.55	2.55
Italy	4	4	8	4.17	1.55	2.27
South Africa	0	8	8	0.00	3.10	2.27
Spain	0	6	6	0.00	2.33	1.70
Denmark	0	6	6	0.00	2.33	1.70
Netherlands	3	3	6	3.13	1.16	1.70
Other	33	63	96	34.38	24.42	27.20
Total	**96**	**258**	**353**	**100.00**	**100.00**	**100.00**

Table 4 reflects that the contribution of India to other countries in collaboration towards publication. The share of India was 353(22.8%) number of publications with 55 Collaborating countries during the selected period of 2003 to 2014. The collaboration increased from 2003 and 2008 to 258(73.1%) between 2009 and 2014. During the period among India's top 15 collaborating countries and his shares are shown in Table 4. The United States has 72(20.40%) papers, followed by the United Kingdom 28(8.14%); China has 23(7.75%), etc. in the process of collaboration with India.

7.5. Top 15 Author's Contribution, Citation, and h-index

Table 5 shows that top 15 Indian authors contribution of 134 papers in Pollution control research publication out, citations and h-index. From this study a highest number of 17(12.69%) papers published Bandyopadhyay, A. and has 104 citations, h-index 5, followed by Biswas, M.N. 13(9.70%) papers 262 citations and h-index 7, Ravindranath K., has 12(8.96%) papers, 266 citations and h-index -8 and Meikap, B.C. has 12(8.96%) papers 5 citations and h-index 1.

Table 5: *Contribution of top 15 authors, citation, and h-index in pollution control*

S. No.	Author	Publications	%	Citations	h-index
1	Bandyopadhyay, A.	17	12.69	104	5
2	Biswas, M.N.	13	9.70	262	7
3	Rabindranath, K.	12	8.96	266	8
4	Meikap, B.C.	12	8.96	5	1
5	Khare, M.	11	8.21	5	1
6	Devotta, S.	9	6.72	118	4
7	Abbasi, S.A.	7	5.22	146	6
8	Singh, N.	7	5.22	237	6
9	Prasad, M.N.V.	7	5.22	465	6
10	Ghose, M.K.	7	5.22	146	5
11	Philip, L.	7	5.22	121	6
12	Mujumdar, P.P.	7	5.22	208	7
13	Freitas, H.	6	4.48	463	6
14	Gautam, S.P.	6	4.48	3	1
15	Taneja, A.	6	4.48	66	3
Total		**134**	**100.00**		

7.6. Type of Documents

Table 6: *Type of documents in blocks*

S. No.	Document Type	2003-08	2009-14	2003-14	2003-14 %
1	Article	534	673	1206	77.76
2	Conference Paper	56	162	218	14.06
3	Review	32	63	95	6.13
4	Editorial	3	10	13	0.84
5	Book Chapter	0	9	9	0.58
6	Letter	2	3	5	0.32
7	Short Survey	2	0	2	0.13
8	Erratum	1	0	1	0.06
9	Article in Press	0	0	1	0.06
10	Note	0	1	1	0.06
	Total	**630**	**921**	**1551**	**100.00**

Table 6 very clear to state that the block year wise different type of bibliographic form involved towards the research publications on Indian pollution control Research output. During 2003-2014, a maximum number of 1206(77.76%) papers are contributed in the article. Followed by conference paper was 218(14.06%) in the second place and Review with 95(6.13%) papers in the third place and leaving Editorial, Book Chapter, Letter and Short survey with less number of publications as cited below.

7.7. Relative Research Effort

The relative research effort was being measured by the Publication Efficiency Index (PEI), and it is based on the references appended to the research articles by the authors. PEI is calculated by the formula used by Guan, J., & Ma, M. (2007).[17]

$$PEI = \frac{TNC_i/TNC_t}{TNP_i/TNP_t}$$

Where,
TNCi = total number of references in a year,
TNCt = total number of references for all the years
TNPi = total number of papers in a year,
TNPt = total number of papers for all the years

If the value of PEI is greater than 1 for a country, it indicates that the impact of publications is more, and the research effort is highly devoted to that particular country. Table 7 describes the year-wise

Table 7: *Publication Efficiency Index*

Year	Publications	Reference	ARPP	PEI
2003	90	1527	16.97	0.68
2004	117	2366	20.22	0.81
2005	90	2059	22.88	0.91
2006	129	2947	22.84	0.91
2007	111	2584	23.28	0.93
2008	93	2161	23.24	0.93
2009	104	3454	33.21	1.33
2010	161	3698	22.97	0.92
2011	182	5057	27.79	1.11
2012	167	5637	33.75	1.35
2013	143	4548	31.80	1.27
2014	164	6389	38.96	1.56
2003 -2008	630	13644	21.66	0.87
2009 -2014	921	28783	31.25	1.25
2003 -2014	**1551**	**42427**	**27.35**	**Avg. = 1.06**

Publication Efficiency Index (PEI). PEI has been calculated from of 2003-2014 at 1551 publications. The years 2009, 2011-2014 shows a higher impact of publications comparatively to the other years. Further, it is found that the average reference per paper is 27.35.

7.8. Top 15 Indian Institution Contributions, Citation, and h-index

Table 8: *Top 15 Indian Institutions contribution, citation, and h-index*

S. No.	Name of Indian Institution	TP	TC	ACP	h-index
1	National Environmental Engg. Research Institute India	76	1063	13.99	18
2	Indian Institute of Technology Delhi	63	811	12.87	17
3	Indian Institute of Technology Roorkee	40	1098	27.45	12
4	Indian Institute of Technology, Kharagpur	37	617	16.68	13
5	Banaras Hindu University	24	382	15.92	13
6	Anna University	24	244	10.17	6
7	The Energy and Resources Institute India	23	183	7.96	7
8	Indian Institute of Technology, Madras	23	310	13.48	8
9	Indian Institute of Science	21	369	17.57	11
10	Indian Institute of Technology, Kanpur	21	370	17.62	11
11	Jadavpur University	19	118	6.21	6
12	Central Leather Research Institute India	19	289	15.21	9
13	Indian Institute of Technology, Guwahati	18	219	12.17	7
14	Aligarh Muslim University	18	192	10.67	7
15	Central Pollution Control Board India	18	135	7.50	4
Total		**444**			
Indian Pollution Control Output		**1551**			
Share of top 15 Indian Institutions Pollution Control output		**28.63**			

Table 8 shows the top 15 Indian Institution contributions, citation, average citation per paper and h-index. During the period, a total number of 1551 publications contributed by 160 institutions. Out of that, the top 15 institutions contributed 444 (28.61%) number of publications. The National Environmental Engineering Research Institute leads the table with 76 number of publications; 1063 citations with an average citation per paper of 13.99 and have the credit of having more h-index of 18. The Indian Institute of Technology, Delhi placed in the second place with 63 publications; 811 citations with an average citation per paper of 12.87 and the h-index was 17. The Indian Institute of Technology, Roorkee credited with the third place with 40 publications; with maximum no. of citations of 1098 at 27.45 as average citation per paper and an h-index of 12. The status of other twelve institutions is cited in the table according to the chronological order of the number of publications.

8. Findings and Conclusion

Through the Scientometric analysis, it is found that India was placed in the third rank towards publishing more number of publications with a publication share of 1551 out of the total number of publications of 28445 research papers during the study period of 2003 to 2014. United States is top the table leaving China in the second place with 6446 (22.66%) and 6130 (21.55%), respectively. The year wise publication share on Indian-International collaborated papers during 2003-2014 was 353(22.76%) papers. A maximum number of 1206(77.76%) papers are contributed in the form of Journal article. The years 2009, 2011-2014 shows the higher impact of publications of India comparatively to the other years.

Further, it is found that the average reference per paper is 27.35. 160 research institutions of India involved in publishing 1551 research publications on Pollution Control. It is highly appreciable that The National Environmental Engineering Research Institute published 76 research papers, which was considered as the most number of publications on pollution control in India which also gains maximum h-index of 18. Being the pollution is increased day by day using various aspects and innovation, it is essential to control the pollution to developing a healthy society. Therefore, all the funding agencies are requested to allocate more funds to do much more research on Pollution Control for the betterment of the society.

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