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A Scientometric Analysis of Indian Water Resources Research Output during the period of 2001-2020

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ABSTRACT

The study looks at International and Indian publications on water resources from 2001 to 2020, using scientometrics tools to assess the papers and determine the trend. Web of Science, a bibliographical and citation database provided by Clarivate Analytics that enables access to the highest literature, resulted in a total of 11184 articles for research. It also compares the performance of other forms of scientometric measures from India, such as the number of publications, citations, relative growth, doubling time, activity index, and collaboration. Over the last two decades, India's water resources have grown at an exponential rate.

KEYWORDS: Scientometrics, Water resources, RGR, Doubling time.

INTRODUCTION

Scientometrics is a field that studies the organization and growth of knowledge by analyzing scientific publications. Scientometric approaches are used to examine a publication's quantitative and qualitative aspects. It is a scientific field that investigates the evolution of science using quantitative measurements of scientific information, such as the number of scientific articles published during time, their citation impact, and so on. Scientometrics, which is commonly used similarly with bibliometrics, is a Russian term. Scientometrics research covers studies on the scattering and growth of literature, author productivity, document obsolescence, scientific papers distribution by country, language, and other topics that help measure the evolution and trend of research.

NEEDS OF THE STUDY

Both human life and the environment depend on water. Without water, human life would be impossible to sustain. Human life is always dependent on fresh water, and many natural water bodies are used for daily household tasks.

Water is a significant natural resource that has a unique place among other natural resources. Man's impact on water resources has been negligible for many years. Water's natural properties include its ability to self-purify and its ability to regenerate during the water cycle. This created the appearance of immutability and inexhaustibility of water supplies, which were seen as a free gift from nature. A negligent attitude towards the use of water resources has developed, with the belief that the purification of waste water or the protection of natural water bodies requires just the bare minimum of expenditure.

OBJECTIVES OF THE STUDY

The main objectives of the study is to present the growth and progress of water resources research during 2001 to 2020, as per the web of science database and make the quantitative and qualitative assessment by way of analyzing various features of research such as,

1. To study the year wise growth of scientific/ research publications and citations,
2. To identify and analyses the relative growth rate and doubling time of research productivity on water resources;
3. To analyses the research collaboration;
4. To identify the source of publications;
5. To identify journal impact factor;
6. To assess the institution wise research concentration; and
7. To identify country wise collaborative distribution of publications and highly cited papers

METHODOLOGY

The study is based on scientific outputs in Indian water resources, as measured by the Social Science Citation Index (SSCI), Science Citation Index (SCI), and Arts and Humanities Citation Index (AHCI) (A&HCI). For this analysis, the years 2001 to 2020 were studied. To gain an overall sense of the quantity of the water resources literature, a search was conducted in the Web of Science (WOS) database. SSCI, SCI, and A&HCI were searched by topic (SU) field (Water Resources) by limiting it to the period between 2001 and 2020. Its evaluation was based on Scientometrics parameters including authors, countries, institutions, journals, growth rate, doubling time, and subject areas.

DATA ANALYSIS AND INTERPRETATION

1. Growth of Publications of World and India in Water Resources

The growth rate of research papers in the field of water resources in the world and in India from 2001 to 2020. India's average citations per paper and worldwide publication share During the years 2001-2020, India produced 11,184 publications and obtained 1, 84,792 citations, with an average citation per paper of 23.41. In India, research output in the field of water resources has increased from 178 in 2001 to 1,214 by 2020; in 2016, 1024 research publications were published in the field of water resources. The number of publications published in India is constantly rising year after year.

During the period 2001-2020, India's global publications share was 4.23 %, up from 2.78 percent in 2001 to 5.29 percent in 2020. Similarly, global research output in the field of water resources has increased from 6409 in 2001 to 22957 in 2020. The trend is higher, indicating a faster rise in research output when compared to global research output.

Table 1: Growth of Publications of World and India in Water Resources

Year	World TP	Indian TP	% TP Share	ACPP
2001	6409	178	2.78	36.55
2002	6370	145	2.28	43.90
2003	6464	192	2.97	33.44
2004	6701	205	3.06	42.04
2005	6899	214	3.10	43.72
2006	7974	262	3.29	34.63
2007	8612	313	3.63	27.75
2008	9547	405	4.24	28.92
2009	10386	441	4.25	22.92
2010	10731	513	4.78	27.16
2011	11644	574	4.93	26.60
2012	12462	642	5.15	19.81
2013	13905	637	4.58	17.91
2014	14369	730	5.08	15.07
2015	15896	831	5.23	14.40
2016	18336	1061	5.79	11.36
2017	17162	808	4.71	8.87
2018	18586	902	4.85	6.96
2019	19854	917	4.62	4.95
2020	22957	1214	5.29	1.33
Total	**245264**	**11184**	**4.23**	**23.41**

TP=Total Publications, ACPP= Average Citations per Publications

2. Relative Growth Rate and Doubling Time World v/s India

The growth rate of whole contributions has been measured on the basis of RGR and Dt model, which is developed by Mahapatra in 1985. RGR is a calculated to analyze the increase in the number of publications on time and the Dt is directly related to RGR. Table 2 depicts the relative growth rate and Doubling time required for the world and India to double their output of water resources. Over a twenty-year period, the relative growth rate of global output has steadily declined from 0.69 to 0.11. (2001-2020) the doubling time (Dt) had increased correspondingly from 1.00 to 6.43. The global average growth rate and doubling time are 0.220 and 3.522, respectively.

Table-2 shows that Indian output has significantly declined over a twenty-year period, from 0.60 to 0.16. (2001-2020) this expansion could be attributed to the emergence of major scientific institutions, which resulted in increased scientific research. In the same time period, the doubling time has increased from 1.16 to 4.38. The average growth rate and doubling time for Indian output are 0.255 and 2.893, respectively.

Table 2: Relative Growth Rate and Doubling Time World v/s India

Year	World TP	RGR	Dt	India TP	RGR	Dt
2001	6409			178		
2002	6370	0.69	1.00	145	0.60	1.16
2003	6464	0.00	161.36	192	0.04	16.33
2004	6701	0.03	27.22	205	0.16	4.23
2005	6899	0.03	21.32	214	0.05	12.85
2006	7974	0.09	7.74	262	0.13	5.43
2007	8612	0.11	6.36	313	0.19	3.67
2008	9547	0.09	7.65	405	0.22	3.12
2009	10386	0.09	7.43	441	0.16	4.22
2010	10731	0.06	12.01	513	0.12	5.77
2011	11644	0.06	11.98	574	0.13	5.31
2012	12462	0.07	9.30	642	0.11	6.18
2013	13905	0.09	7.73	637	0.05	13.72
2014	14369	0.07	9.92	730	0.07	10.41
2015	15896	0.07	10.18	831	0.13	5.22
2016	18336	0.12	5.63	1061	0.19	3.60
2017	17162	0.04	19.08	808	-0.01	-56.66
2018	18586	0.01	98.75	902	-0.09	-7.79
2019	19854	0.07	9.54	917	0.06	11.21
2020	22957	0.11	6.43	1214	0.16	4.38

RGR=Relative Growth Rate, Dt= Doubling Time

3. Subject-wise Distributions of Publications in Water Resources

Water resources research has been divided into the top ten disciplines (as reflected in WOS database). During the period 2001-2020, only four fields of study accounted for the majority of publications. More than 1000 publications were contributed to four domains, including engineering (5522), environmental science ecology (3863), geology (2929), and meteorology and atmospheric sciences (1514). The top four subfields receive 85.65% of the country's water resources research publications.

The share of cumulative output of Indian water resources research during 2001-2020, the maximum research priority Engineering(5,522 publications, 34.21%share) is assigned to Environmental Sciences Ecology in India during1999–2013, followed by water resources research in other application subjects are: Geology (),Meteorology Atmospheric Sciences (1514 publications,9.38% share), Agriculture(947 publications,5.87% share),Marine Freshwater Biology (658 publications,4.08% share), Science Technology Other Topics (231 publications,1.43% share),Toxicology (189 publications,1.17% share), Public Environmental Occupational Health (187publications,1.16%share),Oceanography (102 publications,0.63% share).

Table 3: Subject-wise Distributions of Publications in Water Resources

S. No	Subjects	Records	%	Cum	Cum%
1	Engineering	5522	34.21	5522	34.21
2	Environmental sciences ecology	3863	23.93	9385	58.14
3	Geology	2929	18.15	12314	76.29
4	Meteorology atmospheric sciences	1514	9.38	13828	85.66
5	Agriculture	947	5.87	14775	91.53
6	Marine freshwater biology	658	4.08	15433	95.61
7	Science technology other topics	231	1.43	15664	97.04
8	Toxicology	189	1.17	15853	98.21
9	Public environmental occupational health	187	1.16	16040	99.37
10	Oceanography	102	0.63	16142	100
		16142	**100**		

4. Impact of journals of Indian contributions in Water Resources

As per table 4 the impact factor journals on water resources publications in the world. The impact factor is a measure of the frequency with which the average article in a journal has been cited in a particular year. It is used to measure the important or rank of a journal by calculating the times its articles are cited. Based on the observation major the most preferred journal by the authors are Desalination And Water Treatment (USA) with 1308 papers, Natural Hazards with (USA) 788 papers, Environmental Earth Sciences with (USA) 756 papers, Desalination Amsterdam (Netherlands) with 598 papers, Journal Of Hydrology (Netherlands) with 444 papers.

Based on the average citations per paper the Desalination Amsterdam Netherlands, holds the first position (41.33), followed by Journal Of Hydrology Netherlands (29.28), Water Resources Management Netherlands (24.17) Journal Of Water Process Engineering Netherlands (12.69), Environmental Earth Sciences USA (12.09), Natural Hazards USA (11.32), and Journal Of Hydrologic Engineering USA (11.15).

Table 4: Impact of journals of Indian contributions in Water Resources

S. No	Source/Journals	Countries	TP	TC	ACPP	H Index	Impact Factor
1	Desalination And Water Treatment	USA	1308	9983	7.63	33	0.896
2	Natural Hazards	USA	788	8922	11.32	41	2.427
3	Environmental Earth Sciences	USA	756	9142	12.09	40	2.18
4	Desalination Amsterdam	Netherlands	598	24713	41.33	76	7.098
5	Journal of Hydrology	Netherlands	444	12999	29.28	54	4.5
6	Water Resources Management	Netherlands	404	9766	24.17	51	2.924
7	Water Science And Technology	England	327	2585	7.91	22	1.638
8	Journal Of Water Process Engineering	Netherlands	323	4098	12.69	32	3.465
9	Journal of Irrigation And Drainage Engineering	USA	316	2933	9.28	26	1.409
10	Journal Of Hydrologic Engineering	USA	312	3478	11.15	27	1.594

TP=Total Publication, TC=Total Citations, ACPP= Average Citations per Publications

5. Organizational Productivity in the field of Water Resources

As per table 5 the research productivity of top 10 most productive Indian organizations on water resources contributed 4351 publications with an average of 435.1 publications per institutions. Out of 10 organizations five institutes registered higher number of publications than the above group average. Such as Indian Institutes Of Technology (IIT) Kharagpur (1957 publications), National Institute Of Hydrology Roorkee (415publications), National Institute Technology (NIT) Warangal (362 publications), Indian Institute Of Science (IISc) Bangalore, (324 publications), Anna University Chennai (319 publications).The total publications published by these 10 research organizations received 89,963 citations, with an average of 20.22 citations per publication. Four institutes scored higher citations than the group average. Such as National Institute of Hydrology, Roorkee with average citations per publication of 26.15, followed by Indian Institutes Of Technology (IIT) Kharagpur, 22.36 citations per publication, Indian Institute Of Science (IISc) Bangalore, 21.70citations per publication and Anna University Chennai, 20 citations per publication.

The average *h*-index of 10 organizations varies from 24 to 85, with the average value of *h*-index during 2001-2020. Out of 10 organizations, only 6 organizations had scored higher *h*-index values than the average values 0f 10 organizations. Such as Indian Institutes Of Technology (IIT) Kharagpur with h-index value 85, followed by National Institute Of Hydrology Roorkee with h-index 55,Indian Institute Of Science (IISc) Bangalore with h-index 44, National Institute Technology (NIT) Warangal, with h-index 39 and Anna University Chennai with h-index 36.

Table 5: Organizational Productivity in the field of Water Resources

S. No	Organisation	TP	TC	ACP	H Index
1	Indian Institutes Of Technology Kharagpur	1957	43767	22.36	85
2	National Institute Of Hydrology Roorkee	415	10854	26.15	55
3	National Institute Technology Warangal	362	6052	16.72	39
4	Indian Institute Of Science Bangalore	324	7030	21.70	44
5	Anna University Chennai	319	6500	20.38	36
6	Indian Institutes Of Technology Roorkee	226	2968	13.13	25
7	Bhabha Atomic Research Centre Mumbai	212	2664	12.57	24
8	Council Of Scientific And Industrial Research New Dehli	199	3440	17.29	31
9	Indian Institutes Of Technology Guwahati	173	1950	11.27	24
10	Aligarh Muslim University Aligarh	164	2744	16.73	28

TP=Total Publication, TC=Total Citations, ACPP= Average Citations per Publications

6. International Collaborations

Table 6 describes the most productive countries along with the India during 2001-2020. The share international publications in the Indian water resources research output was among the different collaborative countries the United States of America has contributed highest number of publications with 702 publications and 15, 823 citations (22.54 ACP and 58 h-index), followed by Australia which ranked second with 270 publications and 6460 citations (23.93 ACP and h-index 39), England 248 publications and 5006 citations (20.19 ACP and h-index 36), Germany 236 publications and 6246 citations (26.47 ACP and h-index 38), Peoples Republic of China 225 publications and

3488 citations (15.50 ACP and h-index 25). Publication collaborations with theses counties showed the quality as well as the future of Indian water resources research.

Table 6: International Collaborations

S. No	Countries	TP	TC	ACPP	H Index
1	USA	702	15823	22.54	58
2	Australia	270	6460	23.93	39
3	England	248	5006	20.19	36
4	Germany	236	6246	26.47	38
5	Peoples Republic China	225	3488	15.50	25
6	Canada	186	4350	23.39	35
7	France	169	4572	27.05	39
8	South Korea	169	2784	16.47	28
9	Malaysia	155	4368	28.18	34
10	Netherlands	147	3581	24.36	32

TP=Total Publication, TC=Total Citations, ACPP= Average Citations per Publications

7. Most productive Authors in Water Resources

Table 7 enumerates the top 10 productive authors in water resources research based on their highest publications over the period of 20 years. Taken into account the number of article published, these authors have together published 1306 publications and received 21,410 citations with an average citation per paper of 16.39.

Kumar, A. is the highly productive author, he contributed 240 publications and received 2993 citations, and average citation per paper is 12.47, Singh, S K. contributed 168 articles and received 1763 citations with 10.49 average citations per paper, Kumar, S. contributed 165 articles and received 2769 citations with 16.78 average citations per paper. Singh R. contributed 129 articles and received 2627citations with 20.36 average citations per paper.

Table 7: Most productive Authors in Water Resources

S.No	Authors	TP	TC	ACPP	H Index
1	Kumar A	240	2993	12.47	26
2	Singh SK	168	1763	10.49	23
3	Kumar S	165	2769	16.78	29
4	Singh R	129	2627	20.36	28
5	Kumar R	122	1887	15.47	24
6	Dey S	116	2044	17.62	26
7	Singh A	97	1931	19.91	25
8	Kumar P	93	1208	12.99	19
9	Kumar M	90	1900	21.11	22
10	Singh VP	86	2288	26.60	26

TP=Total Publication, TC=Total Citations, ACPP= Average Citations per Publications

DISCUSSION AND CONCLUSION

The study intended to find out the Indian and global publication pattern and growth in water resources literature. Based on this study India has produced 11184 publications during the period of 2001-2020, which is reflected in Web of Science database. India's publications are gradually increasing year by year. The global publications share of India during 2001-2020 was 4.23%. It is found that the mean growth rate is 2.33 and the mean doubling time for the research output on research is 48.23.

There is a general progressive increase in the number of publications of water resource literature. However, its relative growth rate has shown a declining trend, indicating that the rate of increase is low in terms of proportion, as demonstrated by doubling time for publications, which is greater than the relative growth of total scientific publication. It indicates a decreasing trend, whereas doubling the time for publication indicates an increasing trend. The publication of data demonstrates that it was published under various headings in the relevant publications.

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