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A scientometric analysis of Indian publication output in clean water and sanitation during 2011-2020

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Abstract

United Nations Sustainable Development Goal 6 (SDG 6) seeks to ensure the availability of safe and affordable access to drinking water and sanitation facilities for all. Research on clean water and sanitation aims to increase access to safe, adequate, and affordable water for people to meet their drinking, sanitation, and hygiene needs. The paper analyses Indian research output in clean water and sanitation on a series of quantitative and qualitative indicators, using the SCOPUS database. The results revealed an increasing trend in scholarly output and identified contributions of India, as well as most productive Indian authors and institutions in the field of clean water and sanitation research. India occupied the third position among the most productive countries while China and the United States occupied the first and second positions. Besides, the Indian Institute of Technology Roorkee was the most productive Indian institution with 172 publications, followed by Indian Institute of Technology Kharagpur (160 publications) and Anna University (140 publications). Environmental Monitoring and Assessment published the maximum number of publications on clean water and sanitation during this period.

Keywords: Clean Water; Sanitation; Scientific output; Bibliometrics; Scientometrics; India

1. Introduction

Sustainable Development Goals (SDG) were set by the United Nations General Assembly in 2015 which are designed with a view to address key social challenges by 2030. SDG 6 i.e. clean water and sanitation is a major global issue in today's world, as issues such as water quality, flooding, and lack of proper waste management hinder sustainable social and economic development. India has been committed to providing its citizens with clean water and sanitation facilities since independence in 1947. India began to make progress on clean water and sanitation problems after 1960, with the main objective of hygiene education. The large population of India and its sheer diversity make it difficult to implement

policies and modest progress has been made on SDG 6. There is no access to clean water for 163 million people in India and 210 million lack access to better sanitation facilities (Sarkar, 2019). According to the report published by NITI Aayog, 75% of households in India do not have drinking water in their household premises and about 84% of rural households do not have access to piped water (Dutta, 2019). There are many sources of water pollution in India, such as sewage, solid waste, mining, and natural disasters, which have severely impacted the quality of water (Ghosh et al., 2020). Global human development is immensely dependent on water quality as it can adversely affect human health, ecosystems, and socio-economic growth. Research on clean water and sanitation is therefore important and crucial to human existence. Successful implementation of SDG 6 in India would require greater precision in the mechanisms of federal governance at both the State/Central levels. Several studies have been undertaken in recent years in India to develop and apply creative and successful strategies and innovations with the potential for high-impact, practical solutions for clean water and sanitation.

In recent years, scientometrics and bibliometrics have been widely applied in various fields to identify the productivity of authors, institutions, and countries, international collaborations, and to identify the research trends in the specific subject area (Sharma et al., 2019). Several studies published in the past have performed a bibliometric and scientometric analysis of scholarly output in the field of clean water and sanitation. Nishy & Renuka performed a scientometric analysis of the water quality research in India from 1986 to 2015 based on data collected from the Web of Science (WoS) database (Nishy & Saroja, 2018). Findings of the study revealed that India occupied the seventh position among the most productive countries in water treatment research in terms of research productivity. Wang Li & Ho carried out a bibliometric analysis of the articles published in water resources journals from 1993 to 2008 (Wang et al., 2011). India was the eighth-most productive country based on the publication output in water resources journals. Yuh-Shan Ho carried out a bibliometric analysis of biosorption technology in water treatment research from 1991 to 2004 based on the Science Citation Index (Ho, 2008). Jacobs et al. performed a scientometric analysis of the publication output on water research in South Africa based on data retrieved from the WoS database (Jacobs et al., 2014). Yuan et al. performed scientometrics analysis of the patent activity on water pollution and treatment in China from 1985–2007 (Yuan et al., 2010). In another study, Zheng et al. carried out a bibliometric analysis of industrial wastewater from 1991 to 2014

based on the Science Citation Index database (Zheng et al., 2015). In this study, a scientometric analysis on Indian research output in clean water and sanitation during 2011-20 was conducted based on the publication data retrieved from the SCOPUS database.

2. Materials and Methods

Information about scientific output was extracted from the SCOPUS database [https://www.SCOPUS.com] by using the search string "TITLE-ABS-KEY (((({Safe} AND ({water access} OR {drinking water})) OR ({clean} AND ({drinking water} OR {water source})) OR ({water} AND ({sanitation and hygiene} OR {sanitation & hygiene} OR {quality} OR {resource}) AND ({water availability} OR {water-use efficiency} OR {water supply} OR {water supplies} OR {clean water} OR {hygienic toilet} OR {hygienic toilets} OR {antifouling membrane} OR {antifouling membranes} OR {anti-fouling membrane} OR {anti-fouling membranes} OR {water management} OR {aquatic toxicology} OR {water toxicology} OR {aquatic ecotoxicology} OR {water ecotoxicology})) OR (({freshwater} OR {fresh water}) AND ({water quality}) AND ({pollutant} OR {pollution} OR contamina*)) OR ({freshwater} AND ({water security} OR {water shortage} OR ({waste water} AND "treatment") OR ({wastewater} AND "treatment") OR {water conservation} OR {water footprint} OR {water infrastructure} OR {water pollution} OR {water purification} OR {water use} OR {water uses} OR sanit* OR sewer*)) OR (({water} AND ({ecosystem} OR {eco-system}) AND ({protection of} OR {endocrine disruptor} OR {endocrine disruptors})) AND NOT {marine}) OR ({water} AND {water management} AND ({pollution remediation} OR {pollutant removal})) OR (({groundwater} OR {ground water} OR {ground-water}) AND {freshwater}) OR (({water pollution} OR {water pollutant}) AND ({waste water} AND "treatment") OR ({wastewater} AND "treatment")) OR {freshwater availability} OR {fresh water availability} OR {water scarcity} OR {open defecation} OR {blue water} OR {green water} OR {grey water} OR {black water})) AND NOT {global burden of disease study}) AND PUBYEAR < 2021 AND PUBYEAR > 2010" (Jayabalasingham et al., 2019).

The retrieved data was exported to MS-excel in CSV format containing the citations and bibliometric information. The list of publications was imported to the benchmarking module of SciVal [https://www.Scival.com] for further analysis. Several publication-quality indicators were employed to help identify publications and citations trends such as citations per paper

(CPP), field weighted citation impact (FWCI), publications in top 10 journal percentiles (%), International collaboration (%) and h-index. The average citation per publication represents the average number of citations received by a paper over a specific period of time. The FWCI compares the total citations received by publications of an entity with the global average for the similar subject field, publication type, and publication year. The global average of the FWCI is taken as 1. Publications in top 10% journal percentiles (%) indicate how many publications of a selected entity are within the top 10% journals indexed in the SCOPUS database. International collaborative papers (%) represent the percentage of papers published with international co-authors. h-index was regarded as the h of Np articles were cited no less than h times each and the other (Np-h) articles were cited no more than h times each (Hirsch, 2005). The study also seeks to analyze the publication growth rate, leading 10 countries, top 10 funding agencies, top 15 Indian institutions, top 10 Indian authors, and top 10 journals publishing research in the subject.

3. Analysis and results

3.1 Characteristics of Publication Output

The year-wise distribution of publication output revealed the progress of research on clean water and sanitation over time (Table 1, Figure 1). Global research output in clean water and sanitation consisted of 85813 publications during 2011-20 and registered an average annual growth rate of 8.08%. India published 5735 publications in the field of clean water and sanitation during 2011-20 at an average annual growth rate of 9.23%. The number of global scientific publications by Indian authors increased from 393 in 2011 to 860 in 2020. India registered an average citation per paper of 14.6 during this period compared to the global average of 16.3 citations per paper.

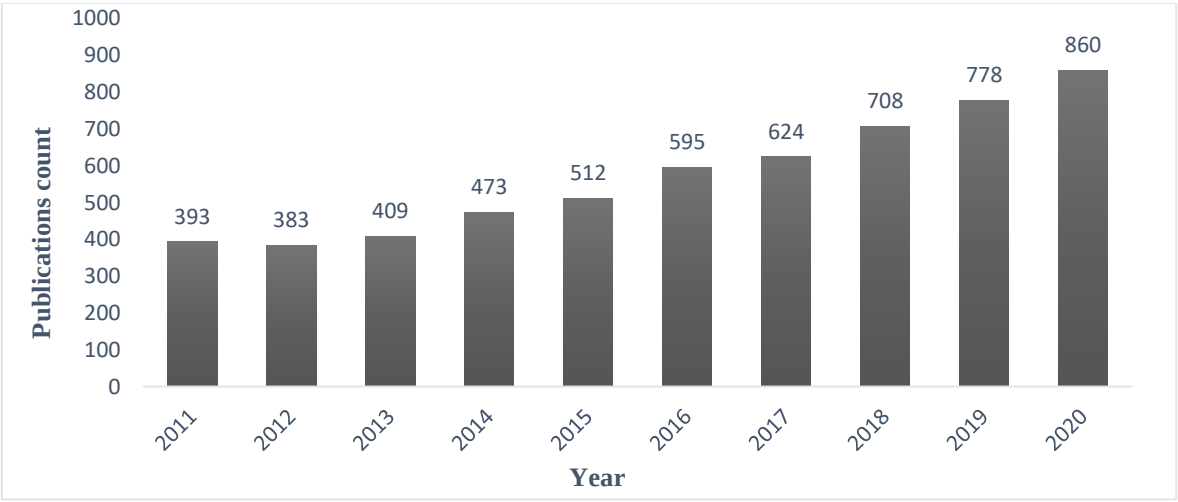

Figure 1. Indian publication output in clean water and sanitation research during 2011-20

Table 1. Global and Indian publication during 2011-20

Worldwide					India				
Year	TP	AGR (%)	TC	CPP	Year	TP	AGR (%)	TC	CPP
2011	6273		177867	28.4	2011	393		9207	23.4
2012	6072	-3.20	168513	27.8	2012	383	-2.54	12445	32.5
2013	6515	7.30	160298	24.6	2013	409	6.79	6973	17.0
2014	7196	10.45	170720	23.7	2014	473	15.65	10930	23.1
2015	7791	8.27	175064	22.5	2015	512	8.25	10096	19.7
2016	8697	11.63	165084	19.0	2016	595	16.21	9846	16.5
2017	9063	4.21	143289	15.8	2017	624	4.87	9086	14.6
2018	10354	14.24	122794	11.9	2018	708	13.46	7378	10.4
2019	11347	9.59	85360	7.5	2019	778	9.89	5868	7.5
2020	12505	10.21	29342	2.3	2020	860	10.54	1881	2.2
2011-2015	33847	-	852462	25.2	2011-2015	2170	-	49651	22.9
2016-2020	51966	-	545869	10.5	2016-2020	3565	-	34059	9.6
2011-20	85813	-	1398331	16.3	2011-20	5735	-	83710	14.6

TP=Total publications; AGR=Annual growth rate; TC=Total citations: CPP=Citations per paper

3.2 Most Productive Countries

The top 10 countries included two Asian countries, four European countries, three American countries, and one Oceanic country (Table 2, Figure 2). The 10 most productive countries generated the vast majority of published papers (81.5%). India ranks 3rd among the top 10 most productive countries in clean water and sanitation research during 2011-20 with a publication share of 6.7%. China tops the list with a global publication share of 21.6%. The United States ranks second (with a publication share of 21%) followed by India, Australia, and the United Kingdom. The United Kingdom registered the highest citation per paper of 24 followed by Australia (23.2), and Spain (22.8). The United States registered the highest h-index (195), followed by China (159), and the United Kingdom (128). Australia published the highest proportion of papers (55.7%) in the top 10% journals indexed in the SCOPUS database. The United Kingdom registered the highest FWCI of 1.92 and published the highest number of internationally collaborative papers (65.3%). Indian authors published 26.1% of papers in the

top 10% journals and 24.7% papers with an international co-author during 2011-20, which was lowest among the top 10 most productive countries.

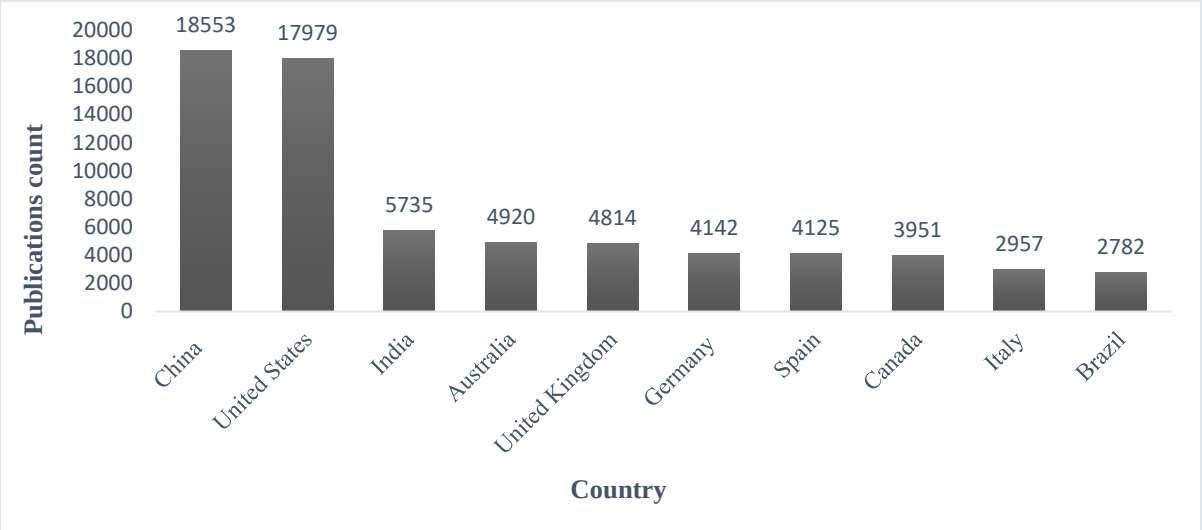

Figure 2. Top 10 most productive countries in clean water and sanitation research during 2011-20

Table 2. Publication data of top 10 most productive countries in clean water and sanitation research during 2011-20

Rank	Country	TP	TP (%)	TC	SC (%)	CPP	FWCI	ICP (%)	OJP (%)	h-index
1	China	18553	21.6	328826	10.4	17.7	1.50	29.7	47.5	159
2	United States	17979	21.0	369811	8.7	20.6	1.47	41.2	51.2	195
3	India	5735	6.7	83710	4.6	14.6	1.15	24.7	26.1	109
4	Australia	4920	5.7	114170	5.2	23.2	1.71	54.7	55.7	126
5	United Kingdom	4814	5.6	115527	4.8	24.0	1.92	65.3	53.6	128
6	Germany	4142	4.8	90390	5.5	21.8	1.64	61.4	48.7	118
7	Spain	4125	4.8	93935	6.2	22.8	1.64	48.8	54.5	109
8	Canada	3951	4.6	81611	4.6	20.7	1.44	52.8	51.4	107
9	Italy	2957	3.4	59631	4.7	20.2	1.67	48.5	44.4	90
10	Brazil	2782	3.2	30838	5.0	11.1	1.03	30.5	27.8	62

TP=Total publications; TC=Total citations; SC=Self citations; CPP=Citations per paper; FWCI= Field weighted citation impact, ICP=International collaborative papers; OJP=Output in top 10 journal percentiles

3.3 Major collaborative partners of India

Research on clean water and sanitation in India became increasingly collaborative over the period studied. A total of 1416 or 24.7% of articles on clean water and sanitation were published by Indian research institutions in collaboration with institutions from outside Africa (Table 2). The United States was the major collaborative partner of India in clean water and sanitation research (366 publications) accounting for 6.4% of India's publication output followed by the United Kingdom (174 publications), Australia (162 collaborative publications), Germany (119 publications), and South Korea (114 publications). Major collaborative partners of India in clean water and sanitation research during 2011-20 is shown in figure 3.

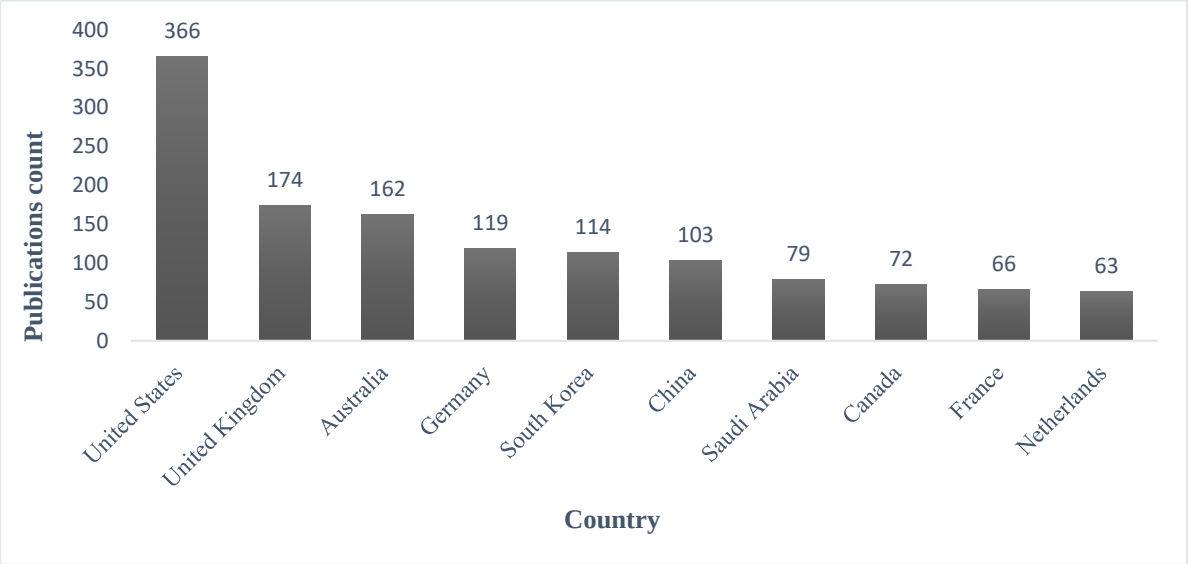

Figure 3. Major collaborative partners of India in clean water and sanitation research during 2011-20

3.4 Subject-Wise Distribution of Indian Publications

Subject-wise distribution of Indian publications in clean water and sanitation research during 2011-20 is shown in Table 3 and Figure 4. The subject areas (as defined by the SCOPUS database) were used as criteria for understanding the distribution of clean water and sanitation research in India during 2011-20. Environmental science accounted for the largest Indian publications share (57.45%), followed by Engineering (18.59%), Agricultural and Biological Sciences (13.76%), Earth and Planetary Sciences (11.80%), and Chemical Engineering (9.26%). Among these subject areas, Chemistry registered the highest citation per paper of 29.5, followed by Chemical Engineering (26.7), and Energy (18.8).

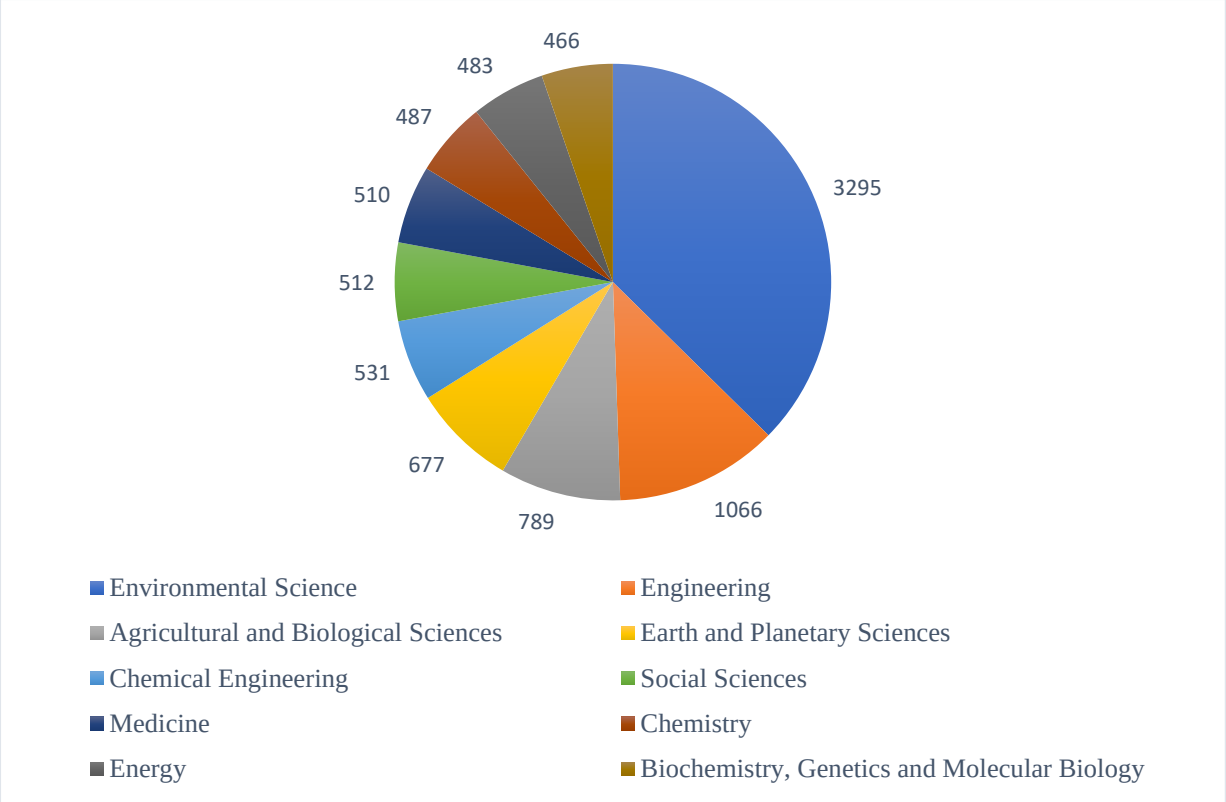

Figure 4. Subject-Wise Distribution of Indian Publications

Table 3. Subject-wise distribution of Indian publications in clean water and sanitation research during 2011-20

S. No.	Subject	TP	% TP	TC	CPP
1	Environmental Science	3295	57.45	58191	17.7
2	Engineering	1066	18.59	6773	6.4
3	Agricultural and Biological Sciences	789	13.76	8246	10.5
4	Earth and Planetary Sciences	677	11.80	7140	10.5
5	Chemical Engineering	531	9.26	14201	26.7
6	Social Sciences	512	8.93	3723	7.3
7	Medicine	510	8.89	7881	15.5
8	Chemistry	487	8.49	14354	29.5
9	Energy	483	8.42	9080	18.8
10	Biochemistry, Genetics and Molecular Biology	466	8.13	5401	11.6

TP=Total publications; TC=Total citations; CPP=Citations per paper

3.5 Top 10 Funding Agencies

Table 4 shows the top ten funding agencies that are financially assisting research activities in the field of clean water and sanitation in India. Department of Science and Technology, Government of Kerala funded 152 publications during 2011-20 and stands first followed by University Grants Commission with 140 publications and Department of Science and Technology, Ministry of Science and Technology with 91 publications.

Table 4. Top 10 funding agencies in the field of clean water and sanitation

S. No.	Name of the funding agency	TP
1	Department of Science and Technology, Government of Kerala	152
2	University Grants Commission	140
3	Department of Science and Technology, Ministry of Science and Technology, India	91
4	Bangladesh Council of Scientific and Industrial Research	84
5	Science and Engineering Research Board	71
6	Council of Scientific and Industrial Research, India	66
7	University Grants Committee	63
8	Indian Council of Agricultural Research	50
9	Ministry of Human Resource Development	49
10	Department of Biotechnology, Government of West Bengal	48

TP=Total publications

3.6 Contribution and Impact of Most Productive Indian Organisations

The research performance of the top 15 most productive Indian institutions in the field of clean water and sanitation during 2011-20 is given in Table 5. These 15 institutions account for 26.4% (1516 publications) of India's total publication output. Indian Institute of Technology Roorkee (172 publications) was the most productive Indian institution, followed by the Indian Institute of Technology Kharagpur (160 publications), and Anna University (113 publications). National Environmental Engineering Research Institute India registered the highest citation per publication of 27.1, followed by Council of Scientific and Industrial Research India (24.2), Indian Institute of Technology Roorkee (23.2). The average citation per paper of these 15 institutions was 17.3. Indian Institute of Technology Kharagpur registered the highest

h-index of 32, followed by the National Environmental Engineering Research Institute India (28), and Indian Institute of Technology Delhi (27). Indian Institute of Technology Roorkee published the highest number of papers with international collaboration (40.1%), followed by the Indian Institute of Technology Madras (37.8%), and National Geophysical Research Institute India (36.6%). Council of Scientific and Industrial Research India recorded the highest FWCI of 1.63. Indian Institute of Technology Kharagpur published the highest proportion of papers (51%) in the top 10% journals.

Table 5. Top 15 Indian institutions in the field of clean water and sanitation research during 2011-20

S. No.	Institution	TP	TC	CPP	FWCI	ICP (%)	OJP (%)	h-index
1	Indian Institute of Technology Roorkee	172	3988	23.2	1.30	40.1	32.9	25
2	Indian Institute of Technology Kharagpur	160	3022	18.9	1.47	33.1	51	32
3	Anna University	140	1922	13.7	1.37	29.3	19.4	25
4	National Environmental Engineering Research Institute India	115	3115	27.1	1.56	15.7	39.8	28
5	Indian Council of Agricultural Research	109	768	7	0.96	22.9	29.5	15
6	Indian Institute of Technology, Bombay	107	1420	13.3	1.23	33.6	41.1	19
7	Indian Institute of Technology Delhi	103	2371	23	1.43	28.2	45.6	27
8	Council of Scientific and Industrial Research India	86	2078	24.2	1.63	20.9	37.5	26
9	Jadavpur University	83	990	12.1	0.93	24.4	25	17
10	Indian Institute of Technology Guwahati	80	714	8.9	0.91	25	43.6	15

11	Indian Institute of Technology Madras	74	1329	18	1.08	37.8	44.3	18
12	Banaras Hindu University	72	1341	18.6	1.32	23.6	32.3	17
13	Vellore Institute of Technology, Vellore	72	1534	21.3	1.15	30.6	26.1	18
14	ICAR - Indian Agricultural Research Institute, New Delhi	72	889	12.3	1.05	26.4	27.7	16
15	National Geophysical Research Institute India	71	1254	17.7	1.07	36.6	22.2	21

TP=Total publications; TC=Total citations; CPP=Citations per paper; FWCI= Field weighted citation impact, ICP=International collaborative papers; OJP=Output in top 10 journal percentiles

3.7 Author Contribution Analysis

The research performance of the top 10 most productive Indian authors in the field of clean water and sanitation during 2011-20 is given in Table 6. The 10 most productive authors together contributed 209 papers and generated 4450 citations during 2011-20. Elango Lakshmanan was the most productive Indian author with 26 publications. Absar Ahmad Kazmi was in second place with 25 publications followed by Shakeel Ahmed with 22 publications. Ajay Singh registered the highest citation per publication of 44.8 among these authors, followed by S. Venkata Mohan (38.1), and Elango Lakshmanan (21.6). Ajay Singh received the highest h-index of 19, followed by S. Venkata Mohan (16), and Elango Lakshmanan (14). Shakeel Ahmed published the highest number of internationally collaborative papers (63.6%), followed by Manish Kumar (61.1%), and Elango Lakshmanan (30.8%). Ajay Singh recorded the highest FWCI of 2.53. S. Venkata Mohan published the highest proportion of papers in the top 10% journals (95.5%).

Table 6. Top 10 Indian authors in the field of clean water and sanitation research during 2011-20

S. No.	Author name	Affiliation	TP	TC	CPP	FWCI	ICP (%)	OJP (%)	h-index
1	Elango Lakshmanan	Anna University	26	561	21.6	1.07	30.8	4.2	14

2	Absar Ahmad Kazmi	Indian Institute of Technology Roorkee	25	394	15.8	0.93	28	32	13
3	Shakeel Ahmed	National Geophysical Research Institute India, Hyderabad	22	349	15.9	1.23	63.6	31.6	11
4	S. Venkata Mohan	Indian Institute of Chemical Technology, Hyderabad	22	838	38.1	1.48	13.6	95.5	16
5	Ajay Singh	Indian Institute of Technology Kharagpur	21	941	44.8	2.53	4.8	66.7	19
6	Jha, Madan Kumar	Indian Institute of Technology Kharagpur	20	399	20	1.63	20	47.1	7
7	Ligy Philip	Indian Institute of Technology Madras	19	230	12.1	1.04	26.3	38.9	9
8	Suhas Pralhad Wani	International Crops Research Institute for the Semi-Arid Tropics, Patancheru	19	146	7.7	0.81	26.3	30	7
9	Manish Kumar	Indian Institute of Technology Gandhinagar	18	336	18.7	2.2	61.1	64.7	10
10	M. M. Ghangrekar	Indian Institute of Technology Kharagpur	17	256	15.1	1	23.5	35.3	10

TP=Total publications; TC=Total citations; CPP=Citations per paper; FWCI= Field weighted citation impact, ICP=International collaborative papers; OJP=Output in top 10 journal percentiles

3.8 Journal Analysis

The list of top 10 journals publishing Indian papers in the field of clean water and sanitation research during 2011-20 is shown in Table 7. The majority of papers on clean water and sanitation research from Indian institutes were published in journals published from outside India. Indian authors published 17% of articles as open access during 2011-20. The top 10 most productive journals publishing Indian papers in the field of clean water and sanitation during 2011-20 together contributed 1065 papers to India's total publication output with a publication share of 18.6% (Table 8). The majority of the papers were published in Environmental Monitoring and Assessment (198), followed by Environmental Science and Pollution Research (171) and Journal of Environmental Management (142). Among these most productive journals, Bioresource Technology registered the highest citation per paper of 48.1, followed by Chemosphere (47.8), and Journal of Environmental Management (47.2). Bioresource Technology received the highest h-index (38) followed by Journal of Environmental Management (34), and Environmental Monitoring and Assessment (33). Chemosphere registered the highest FWCI of 2.77 during this period.

Table 7. Top 10 journals publishing Indian papers in the field of clean water and sanitation research during 2011-20

S. No.	Journal Name	TP	TC	CPP	FWCI	ICP (%)	h-index	CiteScore 2019
1	Environmental Monitoring and Assessment	198	3701	18.7	1.08	11.6	33	3.4
2	Environmental Science and Pollution Research	171	3585	21	1.34	21.6	30	4.9
3	Journal of Environmental Management	142	6700	47.2	2.53	33.8	34	7.6
4	Bioresource Technology	105	5053	48.1	2.15	30.5	38	12.8
5	Chemosphere	88	4205	47.8	2.77	36.4	25	8.8
6	Water Science and Technology	86	549	6.4	0.56	17.4	13	2.9
7	Science of the Total Environment	80	2029	25.4	2.11	72.5	25	8.6
8	Environmental Earth Sciences	75	1072	14.3	0.8	20	18	4
9	Journal of Hazardous Materials	64	1808	28.3	2.15	31.3	26	13.1

10	Nature Environment and Pollution Technology	56	41	0.7	0.03	1.8	3	0.5

TP=Total publications; TC=Total citations; CPP=Citations per paper; FWCI= Field weighted citation impact, ICP=International collaborative papers

3.9 Highly Cited Papers

The top 10 highly-cited documents in the field of clean water and sanitation during 2011-20 are shown in Table 8. "Biochar as a sorbent for contaminant management in soil and water: A review" by Ahmad M. et al. published in the year 2014 in journal "Chemosphere" was the top-cited article with a citation count of 1805. Two more articles published during 2011-20 have received more than 1000 citations so far. These include the articles titled "New generation adsorbents for water treatment" by Ali I. (published in Chemical Reviews) and "Organic and inorganic contaminants removal from water with biochar, a renewable, low cost and sustainable adsorbent - A critical review" by Mohan D. (published in Bioresource Technology). These 10 most cited papers were published in 8 journals including 3 papers in "Journal of Environmental Management" and 1 paper each in Chemosphere, Bioresource Technology, Chemical Reviews, Ecotoxicology and Environmental Safety, Environmental Science and Pollution Research, Journal of Hydrology, and RSC Advances. Among these highly cited papers, 8 papers were published as review, and 2 were published as original article.

Table 8. Top 10 most cited articles published by Indian authors in the field of clean water and sanitation during 2011-20

S. No.	Title	Authors	Year	Source title	Cited by	Reference
1	Biochar as a sorbent for contaminant management in soil and water: A review	Ahmad M., Rajapaksha A.U., Lim J.E., Zhang M. et al.	2014	Chemosphere	1805	(Ahmad et al., 2014)
2	New generation adsorbents for water treatment	Ali I.	2012	Chemical Reviews	1102	(Ali, 2012)
3	Organic and inorganic contaminants removal from water with biochar, a	Mohan D., Sarswat A., Ok Y.S., Pittman C.U.	2014	Bioresource Technology	1098	(Mohan et al., 2014)

	renewable, low cost and sustainable adsorbent - A critical review					
4	Chemical treatment technologies for waste-water recycling - An overview	Gupta V.K., Ali I., Saleh T.A., Nayak A., Agarwal S.	2012	RSC Advances	993	(Gupta et al., 2012)
5	A review on chemical coagulation/flocculation technologies for removal of colour from textile wastewaters	Verma A.K., Dash R.R., Bhunia P.	2012	Journal of Environmental Management	990	(Verma et al., 2012)
6	Low cost adsorbents for the removal of organic pollutants from wastewater	Ali I., Asim M., Khan T.A.	2012	Journal of Environmental Management	681	(Ali et al., 2012)
7	Global review and synthesis of trends in observed terrestrial near-surface wind speeds: Implications for evaporation	McVicar T.R., Roderick M.L., Donohue R.J., Li L.T., Van Niel T.G. et al.	2012	Journal of Hydrology	648	(McVicar et al., 2012)
8	A critical review on textile wastewater treatments: Possible approaches	Holkar C.R., Jadhav A.J., Pinjari D.V., Mahamuni N.M., Pandit A.B.	2016	Journal of Environmental Management	594	(Holkar et al., 2016)
9	Arsenic contamination, consequences and remediation techniques: A review	Singh R., Singh S., Parihar P., Singh V.P., Prasad S.M.	2015	Ecotoxicology and Environmental Safety	495	(Singh et al., 2015)
10	Column with CNT/magnesium oxide composite for lead(II) removal from water	Saleh T.A., Gupta V.K.	2012	Environmental Science and Pollution Research	485	(Saleh & Gupta, 2012)

4. Conclusion

The paper presents a scientometric profile of Indian research output in clean water and sanitation research during 2011-20. It was observed that the scientific output on clean water and sanitation-related research has experienced rapid growth during the past 10 years and this booming research area has expanded into many related fields. China, the United States, and India occupied the top three positions, based on the publication output during 2011-20. The findings of the study revealed that India published 5735 articles during 2011-20 in the field of clean water and sanitation at an average annual growth rate of 9.23%. The United States was the major collaborative partner of India accounting for 6.4% of India's publication output. The top 15 institutions accounted for a 26.4% share of total Indian publication output. Indian Institute of Technology Roorkee was the most productive Indian institution followed by the Indian Institute of Technology Kharagpur and Anna University. Elango Lakshmanan was the most productive author, and Ajay Singh registered the highest citation per paper and FWCI. The Indian publication output in this field increased at exponential rates over the entire study period. It has been adduced therefore that research on clean water and sanitation is a developing field of study. In the current scenario, the importance of research in the field of clean water and sanitation is bound to grow to keep hygiene-related morbidities in check. Though a long way to go, as compared to the United States and China in terms of the number of scholarly output, India's emergence as the third-largest publisher is mainly due to the influence of government policies and funding on research. India published the lowest proportion of papers in the top 10% journals and papers with international co-authorship compared to other most productive countries. During 2011-20, India registered citation per paper of 14.6 which was lower than the global average. Thus, there is a need to improve the quality of research papers. Increased international collaborations will also serve as a catalyst for improving the quality of research output.

Conflict of interest

The author declare no conflict of interest.

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