



A Scientometric Analysis And Assessment On Environmental Science Research Published By The Indian Academicians In Open Access Environment

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Abstract

India has also faced numerous environmental challenges, including air and water pollution, deforestation, and climate change. This study aims to evaluate and analyses the research contribution on environmental science in India for the last five years. The required bibliographic information is obtained from an online Scopus database.

Material and Methods: This study is based on scientometric analysis of Indian environmental research, indexed in the Scopus database. The dataset is carefully examined in the Biblioshiny (using R-package bibliometrix) for analysis and VOSviewer for the visualization of the data. The exported data comprises of 3205 different documents published in open access environment under this study period was analysed using scientometric indicators and parameters.

Results: The analysis evident that there is a steady growth of literature during this period with average annual growth rate is 30.53% and average citation per documents is 1232. It is also found that total 10649 numbers of keywords are used by the authors. The total number of author found in this study is 13579, among which single authors belong to 111 and co-author per document belongs to 5.55 and the International co-authorship is 38.1%. The findings of the study show that 'Sustainability (Switzerland)' journal at the top contributor in field of environmental research and the trendiest topics were environmental pollution, Covid-19, Plastic and Micro-plastic. These research evaluations are benefited to the scientific community, researchers, funding agency, and policymakers to utilise these results to take decisions and directives on environmental science research across the globe.

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Keywords: *Environmental Research, Authorship Pattern, Scientometric Analysis; Indian Research*

Introduction

India is a land of diverse geography, flora and fauna, and environmental challenges. Over the years, the country has faced several environmental issues, such as air and water pollution, deforestation, soil degradation, and climate change¹. India has also been at the forefront of research and innovation in the field of environmental science. However, what often goes unnoticed is its significant contribution to environmental science research. Further, India has also faced numerous environmental challenges, including air and water pollution, deforestation, and climate change. Therefore, it has been a hotbed for environmental research, with several institutions and researchers working towards finding sustainable solutions to these challenges^{2,3}.

India has a rich history of environmental research and has made significant contributions to the field of environmental science. Indian scientists have been actively involved in studying the impacts of climate change on the country's natural resources, including its water resources, agricultural productivity, and biodiversity. Furthermore, India has been exploring sustainable development models that prioritize environmental conservation while promoting economic growth. Researchers have been developing sustainable agricultural practices, promoting green entrepreneurship, and advocating for policies that prioritize environmental sustainability^{4,5}. With the increase of literature on environment, create confusion to find out the trend of the environmental issues or to find out the required documents in the desired area. Thus, there is a need to evaluate the Indian research contribution on environmental science.

Review of Literature

There is a vast body of literature available on Indian research contributions to environmental science. Several studies have highlighted the significance of the country's research in tackling environmental challenges and providing sustainable solutions. Sharma and Singh⁶ analysed the research output of Indian institutions in the field of environmental science over a ten-year period from 2008 to 2017. The authors also noted that the quality of research had improved over the years, with an increasing number of papers published in high-impact journals. Another study⁴ focused on the role of Indian research in promoting sustainable development. The authors noted that these efforts had helped India emerge as a global leader in sustainable development. The study highlighted the significant contributions of Indian researchers in studying the impacts of climate change on the country's water resources. In the area of pollution control⁷. A study analysed the research output of Indian scientists on air pollution. The study found that Indian researchers had made significant contributions to the development of technologies for controlling air pollution, including the development of low-cost air purifiers and the promotion of cleaner fuels⁸. Zhuang³ carried out a scientometric analysis on exploring environmental health inequalities from 1970 to 2020. The study conducted a scientometric visualization on carbon footprint research on WoS datasets from 2008 to 2021⁵. It was found that China had contributed maximum articles globally. Maheswari⁹ conducted on study on mapping of Indian ecology research literature, using WoS datasets from 1999 to 2010. The findings of the study show that 'Current Science' journal at the top contributor in field of ecology research. Roy¹⁰ examine a case study on the scientometric mapping and visualization of environmental science research, based on 1093 publications records in Scopus data from 1989 to 2018.

The bibliometric mapping climate change research in India from the WoS datasets for the year 2005 to 2009. This study finds that majority publication belongs to SA¹¹. Sharma conducted a bibliometric analysis of environmental science research in India over a 10-year period (2008-2017). They analysed research output, publication patterns, and citation trends across various subfields of environmental science⁶. Study conducted on bibliometric analysis of research output and impact in the field of environmental science and technology in India between 1996 and 2015. They analysed publication patterns, citation trends, and collaboration networks to identify trends and research hotspots. Another study conducted on bibliometric analysis of climate change research in India and its impact on water resources. They analysed publication trends, research focus areas, and citation impact to identify research gaps and opportunities⁷. A bibliometric analysis of air pollution research in India, analyzing research output, publication patterns, and citation trends. They identified research gaps and emerging areas of research focus⁸.

Thus, from the above study it is found that many studies were conducted on research contribution on environmental issues of India. But, there is a gap of articles related to current literature trends, particularly when globally leaders came together and committed to make net-zero carbon emissions. Further, there is a gaping of methodological or evaluation of result based on the objectives of few papers where Indian

environmental issues were discussed earlier. The present study on the other hand gives clear pictures to find out the research trends on research contribution on environmental issues of India.

Objective of the Study

The objectives of the study are:

- To measure the growth and citation impact of Indian environmental research published in the open access environment.
- To analyse the most prolific author and their research impact, globally cited documents, and top ten most globally source in the environmental science research in India.
- To find out the top ten subject discipline of published research and the co-occurrence of keywords, recent trend in environmental science research in India
- To identifying the prominent research areas and factorial analysis among environmental science published research from India.
- To find out the patents filled and funding sources for the environmental science research contributions from India.

Material and Methods

This study is based on scientometric analysis of Indian environmental research, indexed in the Scopus database. Scientometrics, an analytical instrument for evaluating a large volume of publications and citations, offers a data-driven manner for a comprehensive analysis and domain understanding¹². The VOSviewer is a software for creation and analysis of network maps of co-authorship, keyword co-occurrences, the collaboration, bibliographic coupling of citations, authors, and journals¹³. The present study is carried out to measure the publication pattern of Indian environmental research published on open access mode in English language from 2018-2022. The bibliographic dataset for this study was downloaded from the Scopus database. The keyword “environment” was used in the search interface of the Web of Science database and retrieved publications data was limited to the “Open Access” published articles from “India” with subject area “Environmental Science” and “English” language only in the time span of last five year. The year-wise data was exported in Excel format with full bibliographic details along with reference and merged in single file for the analysis of data. A total number of 3205 records were retrieved using the above search strategy. The MS-Excel, Biblioshiny-statistical R based software and VOSviewer versions 1.6.17 were used for the analysis of the datasets.

Result and Discussion

General Information of Datasets

The exported dataset comprises of 3205 different documents for this study (Table1). There is a steady growth of literature during this period with average annual growth rate is 30.53% and average citation per documents is 12.32. The data shows that the article published under the study includes mainly journals, books, book chapter, Conference Papers, editorial, and review articles, etc. It is also found that total 10649 numbers of keywords are used by the authors. The total number of author found in this study is 13579, among which single authors belong to 111 and co-author per document belongs to 5.55 and the International co-authorship is 38.01%.

Table-1: General Information	
Data Description	Results
Documents	3205
Annual Growth Rate %	30.53
Average citations per doc	12.32
Author's Keywords (DE)	10649
Authors	13579
Authors of single-authored docs	111
Co-Authors per Doc	5.55
International co-authorships %	38.1
Document Types	
article	2323
review	475

conference paper	274
book	39
editorial	31
book chapter	26
erratum	23

Publications and Citation of Articles Year-wise

In the last five year, the article published from India on environmental science shows the steady annual growth with highest mean total citation in the year 2020 (Table2). The maximum number of publications (961) recorded in the year 2022. The lowest publication recorded (331) in the year 2018, which shows that almost three times articles started publishing in recent year in compare to begging of the period of the steady. Further, it is also found that highest number of mean total citation per articles (25.47) belong to the year 2020.

Year	No. of Articles	MeanTotal CitationPerArticle	MeanTotal CitationsPerYear	CitableYears
2018	331	19.71	3.94	5
2019	545	13.75	3.44	4
2020	551	25.47	8.49	3
2021	817	10.59	5.29	2
2022	961	2.88	2.88	1

Top Ten Most Relevant Sources

The top ten contributed sources are listed in table-3. The majority 216 (6.74%) publications under the Research Contribution on Indian Environmental Science belongs to “Sustainability (Switzerland)” journal, which is followed by the journal “International Journal of Engineering and Advanced Technology” 206 (6.43%) and “IOP Conference Series: Earth And Environmental Science” 174 (5.43%) respectively.

Sources	Articles	Percentage(Out of Total Publications)
Sustainability (Switzerland)	216	6.74
International Journal of Engineering and Advanced Technology	206	6.43
IOP Conference Series: Earth And Environmental Science	174	5.43
SN Applied Sciences	118	3.68
Environmental Science And Pollution Research	101	3.15
International Journal of Engineering And Technology(UAE)	91	2.84
Science of The Total Environment	72	2.25
International Journal of Environmental Research and Public Health	71	2.22
E3S Web of Conferences	62	1.93
3 Biotech	59	1.84

Most Globally Cited Documents

The top ten globally cited documents are arranged in table-4. “COVID-19 outbreak: Migration, effects on society, global environment and prevention/Science of The Total Environment by Chakraborty, I. & Maity, P.” has received highest number of citations (842), followed by “Effect of restricted emissions during COVID-19 on air quality in India/ Science of The Total Environment, by Sharma, S., Zhang, M., Jingsi Gao, A., Zhang, H., & Kota, S.H.” (708) and “Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi, India/ Science of The Total Environment, by Mahato, S., Pal, S., & Ghosh, K.G.” (696), respectively.

Table-4: Most Globally Cited Documents				
Bibliographical Details of the Paper	DOI	Total Citations	TC per Year	Normalized TC
“Chakraborty, I. & Maity, P. (2020). COVID-19 outbreak: Migration, effects on society, global environment and prevention. Science of The Total Environment, 728 138882” ¹⁴	10.1016/j.scitotenv.2020.138882	842	210.50	33.06
“Sharma, S., Zhang, M., Jingsi Gao, A., Zhang, H., & Kota, S.H. (2020). Effect of restricted emissions during COVID-19 on air quality in India. Science of The Total Environment, 728, 138878” ¹⁵	10.1016/j.scitotenv.2020.138878	708	177.00	27.80
“Mahato, S., Pal, S., & Ghosh, K.G. (2020). Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi, India. Science of The Total Environment, 730” ¹⁶ .	10.1016/j.scitotenv.2020.139086	696	174.00	27.32
“Nidheesh, P.V., Zhou, M., Oturan, M.A. (2018). An overview on the removal of synthetic dyes from water by electrochemical advanced oxidation processes, Chemosphere, 197” ¹⁷ .	10.1016/j.chemosphere.2017.12.195	671	111.83	34.04
“Kattge, J, Bönisch, G, Díaz, S, et al. TRY plant trait database – enhanced coverage and open access. Glob Change Biol. 2020; 26: 119–188”	10.1111/gcb.14904	628	157.00	24.65
“Saadat, S., Rawtani, D., (2020). Hussain, C.M. Environmental perspective of COVID-19, Science of The Total Environment, Volume 728” ⁸ .	10.1016/j.scitotenv.2020.138870	483	120.75	18.96
“Vellingiri, B., et. all. (2020). COVID-19: A promising cure for the global panic, Science of The Total Environment, 725” ¹⁹ .	10.1016/j.scitotenv.2020.138277	378	94.50	14.84
“Kumar, V. (2019). Global evaluation of heavy metal content in surface water bodies: A meta-analysis using heavy metal pollution indices and multivariate statistical analyses, Chemosphere, 236” ²⁰ .	10.1016/j.chemosphere.2019.124364	327	65.40	23.78
“Vanapalli, K.R. (2021). Challenges and strategies for effective plastic waste management during and post COVID-19 pandemic. Science of The Total Environment, 750” ²¹ .	10.1016/j.scitotenv.2020.141514	287	95.67	27.11
“Li, J. (2019). Using mussel as a global bioindicator of coastal microplastic pollution, Environmental Pollution, 244” ²² .	10.1016/j.envpol.2018.10.032	262	52.40	19.05

environmental impact, water pollution, risk assessment related terms. The Cluster-2 (Blue Colour) of 7-keywords comprises atmosphere pollution, air quality, and covid-19 related terms.

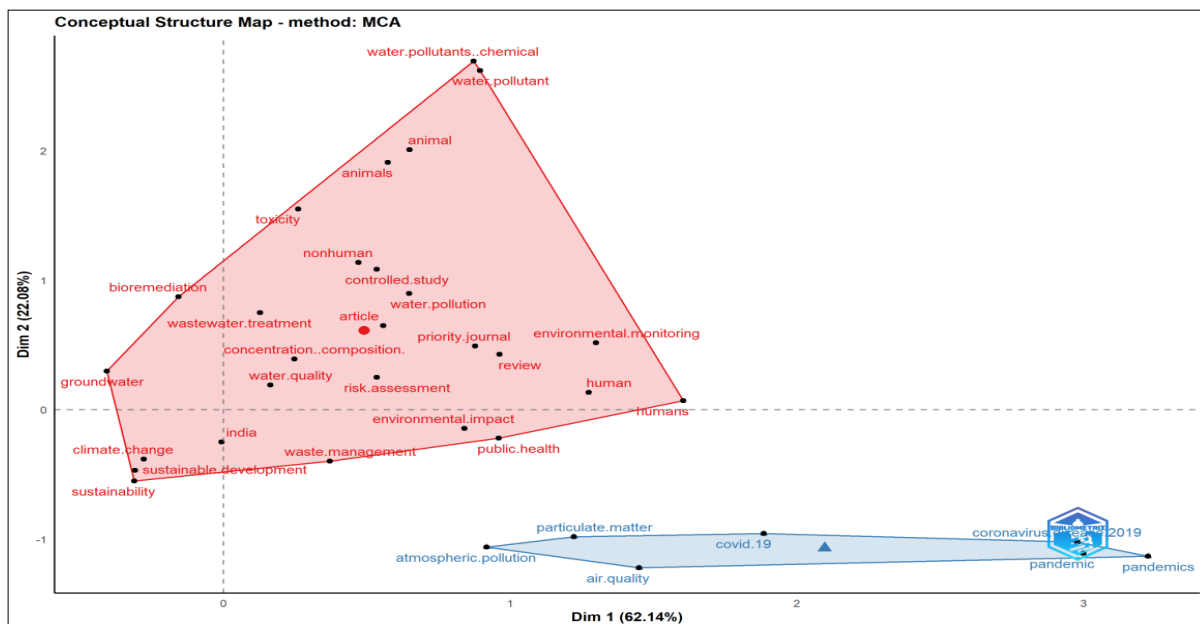


Figure 2: Factorial Analysis

Top Ten Subject Categories of Published Environmental Research

From the figure-3, the graph is clearly depicted that environment related research from India is published in mainly 24 subjects categories journals indexed in the Scopus database. The highest portion of environment research from India is published in the journals of Environmental Science discipline (39%), followed by Engineering (11%), Agriculture & biological Science (8%), and Earth & Planetary Science (8%) respectively.

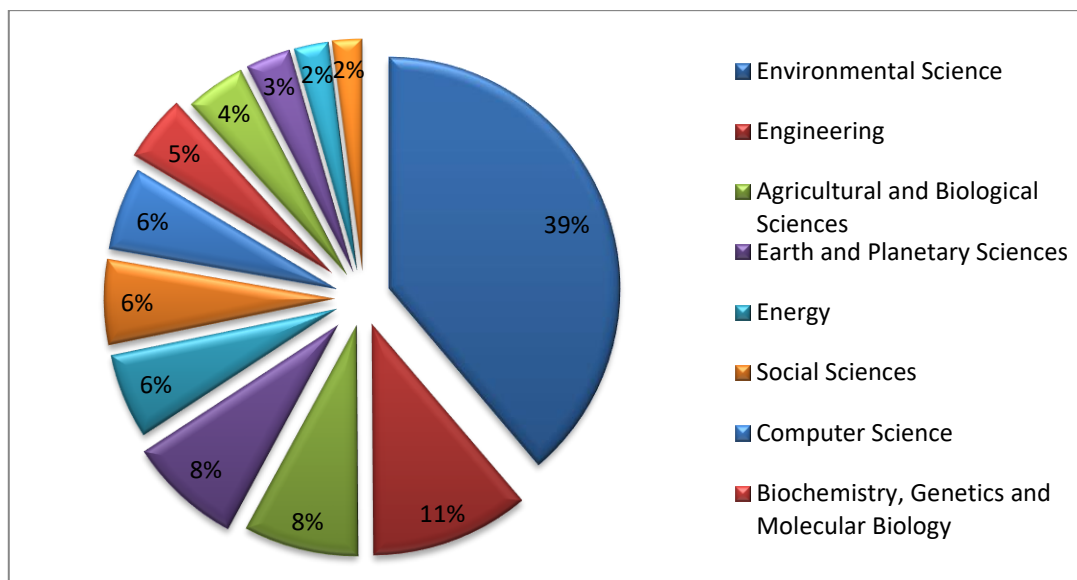


Figure 3: Subject Categories of Published Environmental Research

Recent Trend Topics in Environmental Science Research

To analyses the trending topic on Indian research on environmental science, was carried out based on author keyword from the downloaded dataset and plotted on figure-4. In year 2022, ‘Covid-19’, ‘Plastic’ and ‘Microplastic’ were the most discussed topics. However, in the year 2021, ‘India’, ‘articles’, and ‘human’ were in trend.

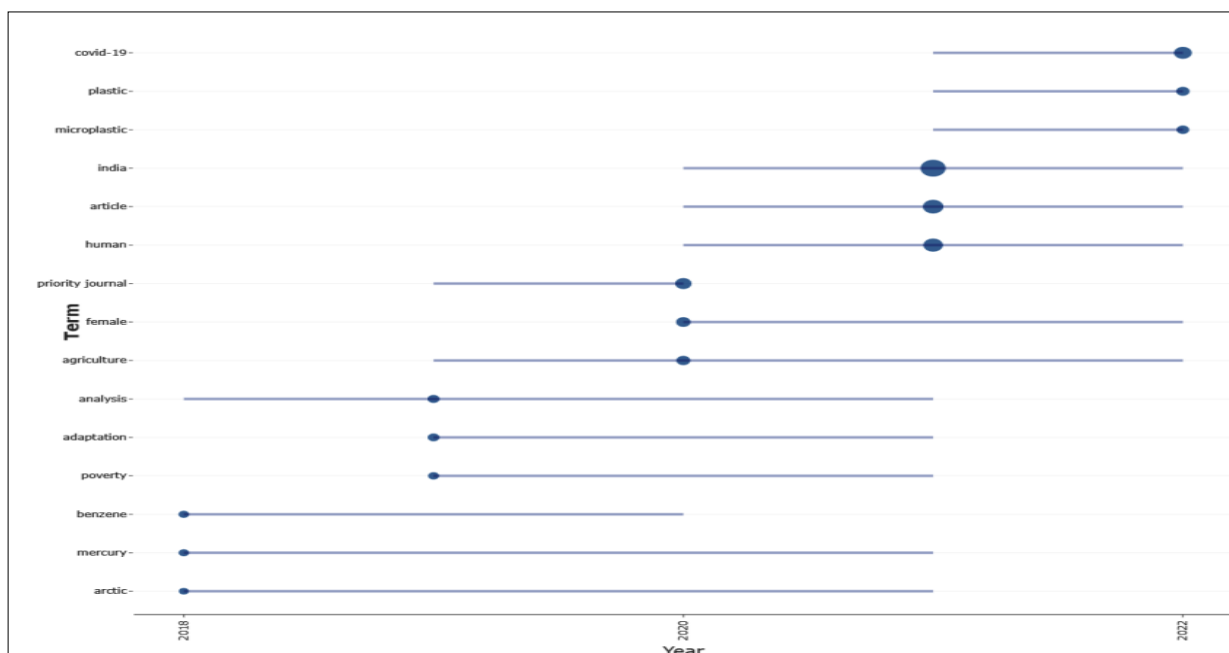


Figure 4: Recent Trends on Indian Environmental Science Research

Funding Source for the Environmental Science Research

From the analysis, it is found that out of 3205 publication records, total 1842 research publications were sponsored by the funding agency. From the figure-5, it is found that DST, Ministry of Science and Technology, India has sponsored maximum 4.68% (150) numbers of publications, followed by UGC (96), and Science and Engineering Research Board(85).

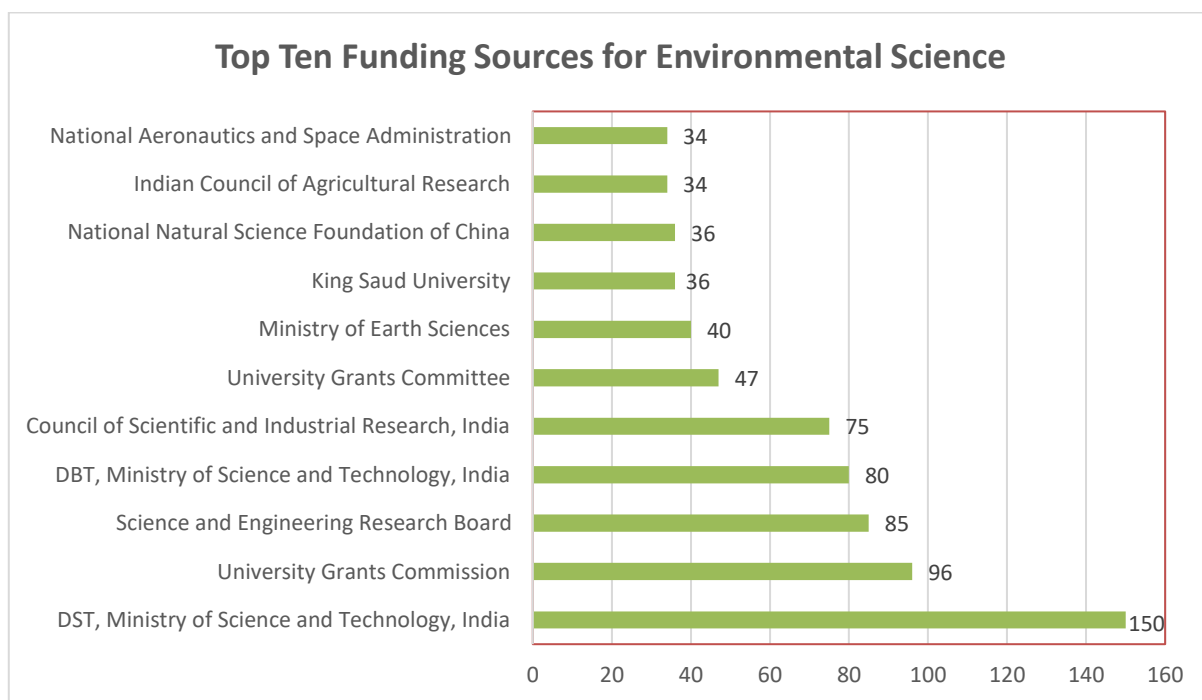


Figure 5: Top Ten Funding Source for Indian Environmental Research

Patent Granted from the study

The total 315 numbers of patents were filed by the Indian Environmental Scientist in the last five year. The highest patents are filled in the office of United State patent & Trademark Office, USA (297), European Patent Office (13), and Word Intellectual Property organization (5). From the figure-6 it is found that the highest (76) number patents were granted in the year 2019, followed by 2021 and 2020.

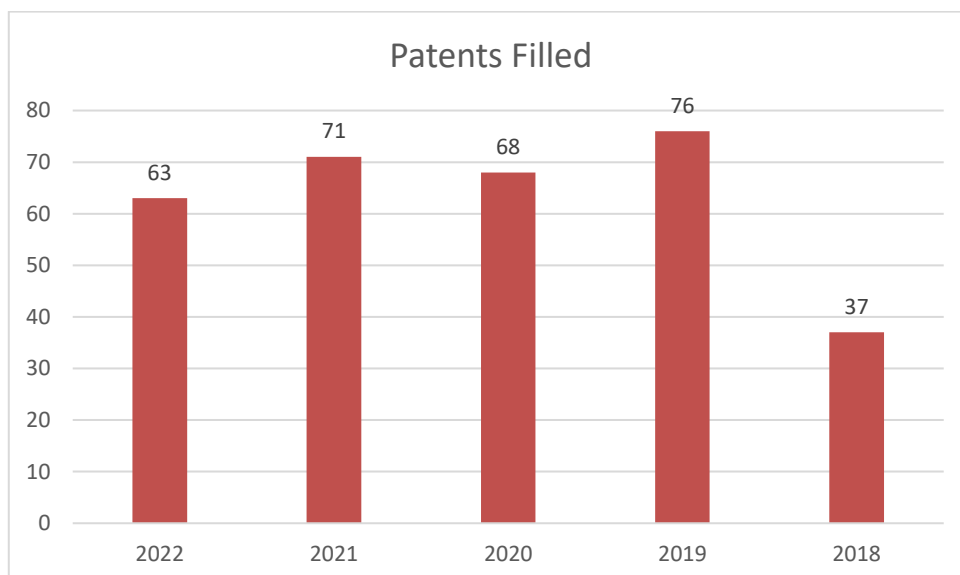


Figure 6: Patents Granted year-wise

Conclusion

The present study analyses the Indian environmental science research contribution for the last five year. The result is the witness to the progress and significant contributions in all the perspectives of environmental research activities in academia. The finding of the study proved that the publications growth and citation impact of Indian environmental science research is praiseworthy and significant amongst the global Open Access research publications and contribution. In this study, it is found that the environment science related open access research from India is published in 24 subject's categories journals indexed in the Scopus. Environmental Science discipline (39%), Engineering (11%), Agriculture & biological Science (8%), and Earth & Planetary Science (8%) journals are mostly selected by the researcher. In the other side, Han⁵ conducted a scientometric visualization on carbon footprint research on WoS datasets from 2008 to 2021. They found that majority of subject falls under environmental science discipline.

In this study, there is steady growth of literature during this period with average annual growth rate is 30.53% and average citation per documents is 1232. The total 13579 number of author are found in this study, among which 111 single authors, 13468 multi-authors and co-author per document belongs to 555. The "Sustainability (Switzerland)" journal, was the highly cited source, followed by the journal "International Journal of Engineering and Advanced Technology". A conducted on study⁹ on mapping of Indian ecology research literature, using WoS datasets from 1999 to 210. The findings of the study show that 'Current Science' journal at the top contributor in field of ecology research.

Chakraborty, I. & Maity, P." has received highest number of citations (842), and the total 13579 numbers of author were contributed to 3205 environmental research publications in open access from the Indian subcontinents during the study. "Kumar, A." is the most prolific First Ranked author, followed by Kumar, P (59) and Kumar, S (57) as ranked second and third respectively. The total 22537 keywords occurs in the analysis, among which 1992 meet the threshold. The network map of co-occurrence of author keywords was visualize in five clusters, 'Pandemic Covid-19' 'India' 'Waste water' 'Non-human' and 'environmental monitoring'. The most trendy topic was Covid-19, Plastic and Microplastic, which was discussed most in the year 2022. A case study^{23,24} on the scientometric mapping and visualization of environmental science research, based on 1093 publications records in Scopus data from 1989 to 2018. He found that sustainable environment were the main area of research.

In the present study, the 1842 research publications were sponsored by the various funding agencies from the India and around the globe. The DST, Ministry of Science and Technology, India was the highest funding source (4.68%), followed by UGC and Science and Engineering Research Board, India. The 315 numbers of patents were also filed by the Indian Environmental Scientist in the last five year. The United State Patent & Trademark Office, USA has granted the highest patents, followed by European Patent Office. This study tried to analysis the open access environmental research productivity of India. The results of the study have proved the objectives and significant insights regarding the environmental science research published in open access by the Indian researchers, and the impact of it around the globe.

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Conflict of interest

The authors declared no conflicts of interest in relation to the work described in the present research article.

Author's contribution

Surendra Kumar Pal, carried out the data collection, dataset examinations, Software analysis, evaluated and analysis of the data, and wrote the first draft of manuscript. Dr. Sudip Bhattacharjee, designed the analysis framework, analyse the results and findings and review and proofread the manuscript.

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Ethics statement and informed consent - This does not apply to the present study.

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