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Quantifying the Trends of DST-funded Environmental Science Research in India: A Scientometric Approach

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ABSTRACT

The primary aim of the study is to analyse the Indian research outputs in the field of Environmental Science funded by the Department of Science and Technology (DST), India. The study focused on unveiling the publication trend, publication type, preferred publication sources, and research themes. The study also aimed to trace the leading authors, organisations, and collaborating nations. A total number of 8938 Indian documents in the field of Environmental Science funded by DST were found to be indexed in the Scopus database. The bibliographic records extracted in BibTeX format were analysed using the Biblioshiny. The study found a rapid growth in publications from 2018 to 2023. Findings also reveal that 88.55 % of documents were articles; and "Environmental Science and Pollution Research" was the top publication source with 387 articles. The study reported that the organisations "Academy of Scientific and Innovation Research", "IIT Kharagpur", and "IIT Delhi" were found to be the most productive as well as most collaborative organisations. The study revealed that India mostly collaborated with the US, Korea, and China to publish the research outputs in the field of Environmental Science funded by DST. Keyword analysis revealed that the themes such as toxicity, adsorption, kinetics, biodegradation, and bioremediation have a high degree of density and centrality, which indicates most of the studies funded by DST are related to these themes. This study provides a comprehensive overview, research trends, and future direction of the field. The findings can help researchers, to know the publication trend, prolific authors, organisations, publication sources, and emerging and declining themes in the field of Environmental Science funded by DST.

Keywords: Scientometrics; Environmental science; Research output; Department of science and technology; India

1. INTRODUCTION

In recent years, most countries have been contributing more and more to the development of technological and scientific aspects supporting a competitive economy necessitating giving the greatest importance to the highly skilled sector and maintaining a strong emphasis on effective R&D for significant results[1]. As a result, the discipline of "Scientometrics" has been conceived. Scientometrics is the quantitative study of research that includes communications within the scientific community, policy development and evaluation, and analysis of scientific output[2]. A wide range of investigations are covered by scientometrics analysis, such as tracking global trends, evaluating publications, assessing citations of authors, sources, and affiliations, and investigating the cognitive structure of science[3]. Governmental and non-governmental funding organisations are essential to the advancement of scientific research in several disciplines, including the social sciences, natural science, and technology[4].

Research funding and project analyses are also quantitative aspects of scientometric research. Within the field of higher education, research is essential. The Government of India has unveiled several programmes that support research projects at higher educational institutions in acknowledgement of its importance. These programmes include various financial options designed to support researchers in various fields. Researchers must possess extensive information regarding these programmes, including how to apply, which funding agencies are involved, what fellowships are available, and how long the money will last. Researchers can efficiently utilise government assistance to further their scholarly endeavours and make a positive impact on the nation's knowledge and innovation base by increasing awareness of and accessibility to these resources[4].

One of the main financing organisations that provide grants for scientific research in India is the Department of Science and Technology (DST) under the Ministry of Science and Technology, India. DST was established in May 1971 and plays a significant role in scientific and technological development responsible for a broad range of duties. The DST is tasked with developing policy, organising S&T efforts, and supporting emerging fields. It also emphasises inclusive development, future discovery, and grassroots advocacy to make sure that

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the advantages of science and technology are available to all facets of society. Using various initiatives, the DST continuously attempts to develop research and development and innovation in India, hence augmenting the country's prosperity and safety[6]. This study intends to carry out a comprehensive examination of the Indian research outputs in environmental science supported by the DST of GOI. Through an examination of the year, kind, and sources of publications, it aims to comprehend the landscape of research financed by the DST based on the data collected from the Scopus database.

2. LITERATURE REVIEW

Pratama[7], *et al.* used bibliometric analysis in their 2024 study to highlight the importance of women's engagement in environmental policy-making. The most significant findings from their analysis revealed a large number of scientific publications which included the following: Air pollution adversely affects pregnant women's health; pollution induces hormonal changes; urban areas suffer environmental pollution issues; and heavy pollution carries hazards. The study promotes women's full participation in environmental decision-making processes and highlights the critical role that women play in tackling these worldwide concerns.

Niknejad[8], *et al.* in their 2022 study performed a bibliometric analysis of green technologies applied to wastewater treatment. To examine scientific publications, they used software tools like VOSviewer and Bibliometrix in RStudio. The study's conclusions indicated that photocatalysis and wetlands were the most often mentioned technologies for improving wastewater treatment because they were frequently referred in the literature. Hou and Wang[9] performed a bibliometric analysis on the energy environment and climate change, gathering data from the SCCI database from 1990 to 2019. They observed that the growth in publications from 2017 to 2019 intensified, with climate change including energy transition and renewable energy serving as the primary theme during that time. In their 2023 study, Patel and Jhalani[10] investigated research shortfalls in the topic of environmental taxes by using the bibliometric analysis method utilising the Scopus database. They looked at the most productive nations, sources, and associations as well as important avenues for future research, global cooperation, and popular terms. The study's conclusions emphasised how crucial it is for social science and environmental science fields to work together to close knowledge gaps and offer new perspectives in the field of environmental taxes.

A study conducted by Kanaujia[11], *et al.* where all the major funded institutions were analysed based on the data collected from WoS during the period from 2001 to 2020. The result showed that the contribution of the centrally funded institutions increased from 62.46 % in 2001-2006 to 72.7 % in 2016-2020. Verma[12], *et al.* undertook a study of funded research in the fields of bibliometrics and scientometrics in their 2023 investigation. Using the WoS database, the research examined publications relevant to the field and technique, identifying several indicators such as the average number of citations annually, growth rates, activity indexing, funding agency productivity, international cooperation, and emerging themes.

One study conducted on health research funding in India by Dandona[13], *et al.* reported that health research funding in India was found to have only a small public contribution, amounting to USD $1.42 billion in 2011–12, or 0.09 % of GDP. Yang[14], *et al.* in 2013 revisited a well-known study conducted by Ginther[15], *et al.* in the year 2011. But the study's findings indicate that the National Institutes of Health (NIH) does not exhibit bias in the way it evaluates grant applications, which differs from their recommendations. The 2015 Ebadi & Schiffauerova[16] study indicates a moderate correlation between funding and the quality and quantity of scientific research. Funded research also has an increasing number of co-authors, and more funding can enable researchers to work on larger projects and produce more research output.

3. OBJECTIVES

- To analyse the documents based on year of publication, type of publication, and source of publication of the DST-funded Indian publications in the field of environmental science.
- To find the leading authors and organisations of the DST-funded publications.
- To understand the collaboration pattern of authors, organisations, and countries behind the DST-funded Indian publications.
- To evaluate the research themes in environmental science funded by DST.

4. SCOPE AND LIMITATIONS

The study's scope is a thorough analysis of DST-funded Indian environmental science research, including trends, publication kinds, authors, and collaborations. It will help researchers and policymakers by offering insightful information about the state of environmental science research in India. The study's chronological breadth may miss recent advancements, and reliance on Scopus data may leave out some publications. The emphasis on DST financing could restrict how much research from other sources is included. The accuracy of the results could be impacted by subjective keyword analysis and methodological limitations.

5. METHODOLOGY

The study included all the Indian publications until 2023 in Environmental Science research funded by DST and indexed in the Scopus database. On February 26, 2024, the search query "AFFILCOUNTRY (india) AND PUBYEAR > 1978 AND PUBYEAR< 2024 AND (LIMIT-TO (SUBJAREA, "ENVI")) AND (LIMIT-TO (FUND-SPONSOR, "Department of Science and Technology, Ministry of Science and Technology, India"))" was used

to extract the documents from the Scopus database. The search query yielded 8938 documents. The bibliographic record of the documents was extracted in BibTeX and CSV format. The basic analysis was done using MS Excel 2021, and the scientometric analysis was carried out using the Biblioshiny.

6. RESULTS AND DISCUSSION

The first Indian Environmental Science research output funded by DST as indexed in the Scopus database was published in 1979. In the realm of environmental science, 8938 documents supported by DST and produced by India between 1979 and 2023 have been discovered. The annual growth rate and average age of the documents were found to be 2.47 % and 4.57 years, respectively. The average citation per document was 20.27. The basic information about the documents is listed in Table 1.

Table 1. Basic information about the documents

Main information about the data	
Description	**Results**
Timespan	1979-2023
Sources (journals, books, etc)	833
Documents	8938
Annual growth rate %	2.47
Document average age	4.57
Average citations per document	20.27
Author's keywords	26028
Authors	19435
Authors of single-authored documents	99
Single-authored docs	107
Co-authors per doc	4.61
International co-authorships %	24.06

6.1 Publication Trend, Document Type, Publication Sources, and Subject Areas

6.1.1 Publication Trend of DST-funded Indian Environmental Science Research

Figure 1 depicts the year-by-year trend of the papers. It is clear that, until 2011, the number of documents grew relatively slowly; nevertheless, from 2011 until 2018, the growth rate accelerated. The number of publications increased at an extremely rapid rate between 2018 and 2023.

6.1.2 Document Type of DST-funded Indian Environmental Science Research

The findings indicated that 88.55 % (7915 articles) of the documents were published in article form; further, 7.63 % were review articles followed by 1.7 % were conference papers, and 1.6 % were book chapters. Figure 2 depicts the form-wise number of documents published by India in the field of environmental science funded by DST.

6.1.3 Publication Sources of DST-funded India Environmental Science Research

The publication sources were assessed to know the most prolific sources where the Indian Environmental Science research outputs funded by DST were published. The highest number of documents were published in the source "Environmental Science and Pollution Research", followed by the sources "Bioresource Technology", "Chemosphere", and "Journal of Environmental Chemical Engineering". The leading ten publication sources based on a number of publications are depicted in Figure 3.

6.1.4 Collaborating Subject Areas of DST-funded Indian Environmental Science Research

Although all the documents (100 %) fall under the primary subject area of Environmental Science, 21.5 % were found to be published in the subject area of Agriculture and Biological Science. Indian Environmental Science research funded by DST mostly fused with the subject of Agriculture and Biological Science (21.5 %), followed by Chemical Engineering (20.2 %), Energy (15.9 %), Engineering (15.1 %), and Chemistry (14.7 %). The ten leading subject areas fused with Environmental Science research are depicted in Figure 4.

6.2 Authors, Organisations, and Collaborating Countries

Social network studies evaluate collaboration between two or more people, nations, or institutions[17]. The

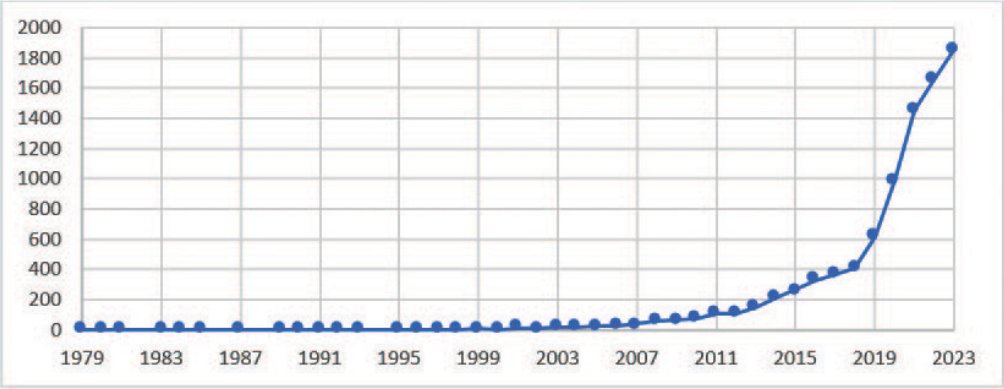

Figure 1. Year-wise publication trend of environmental science research in India funded by DST.

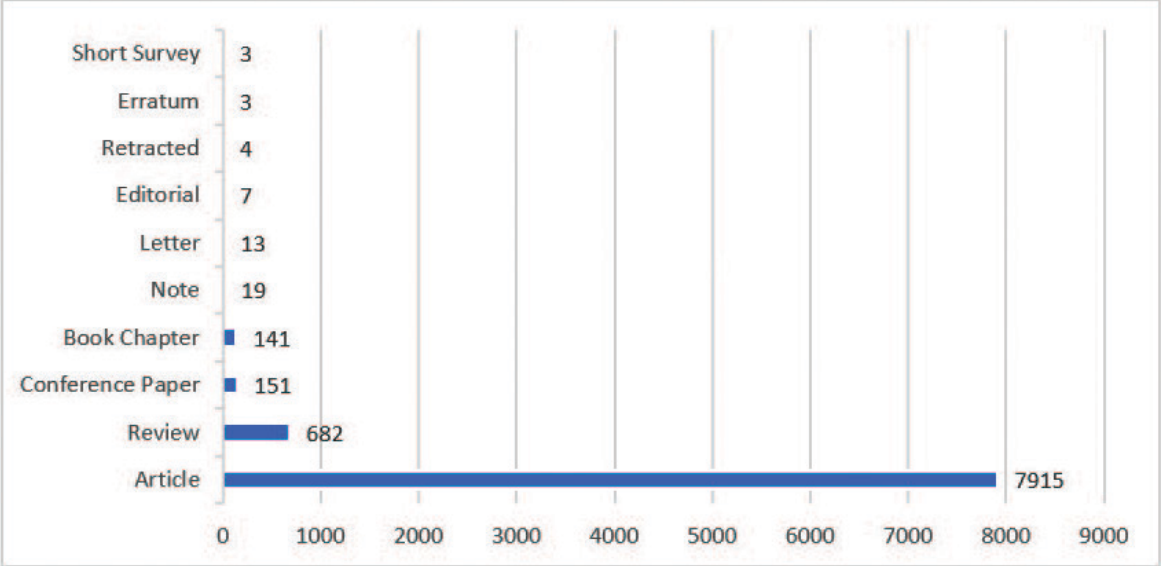

Figure 2. Distribution of type of documents in environmental science research in India funded by DST.

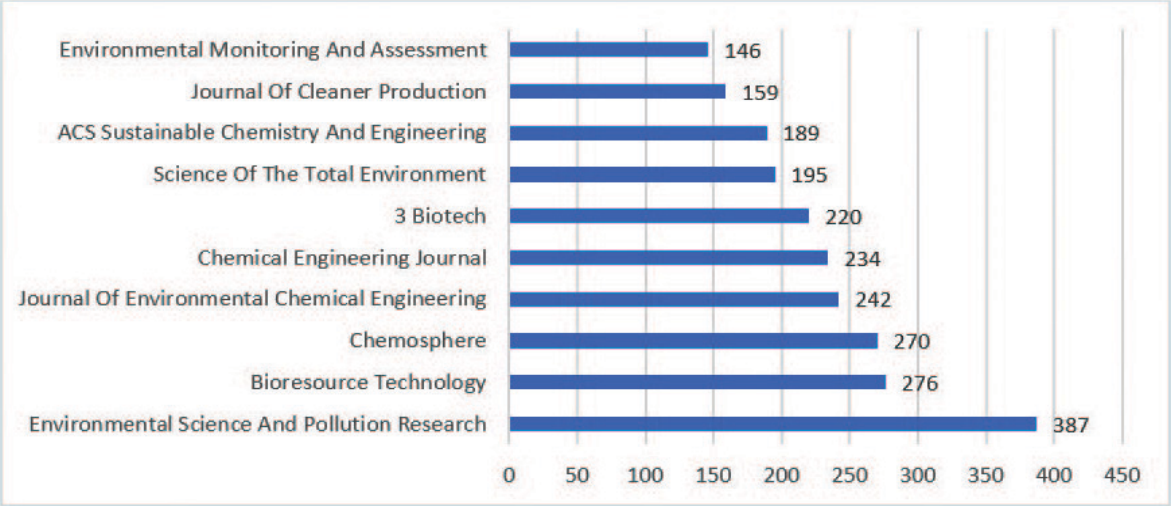

Figure 3. Top 10 publication sources where the environmental science research in India funded by DST were published.

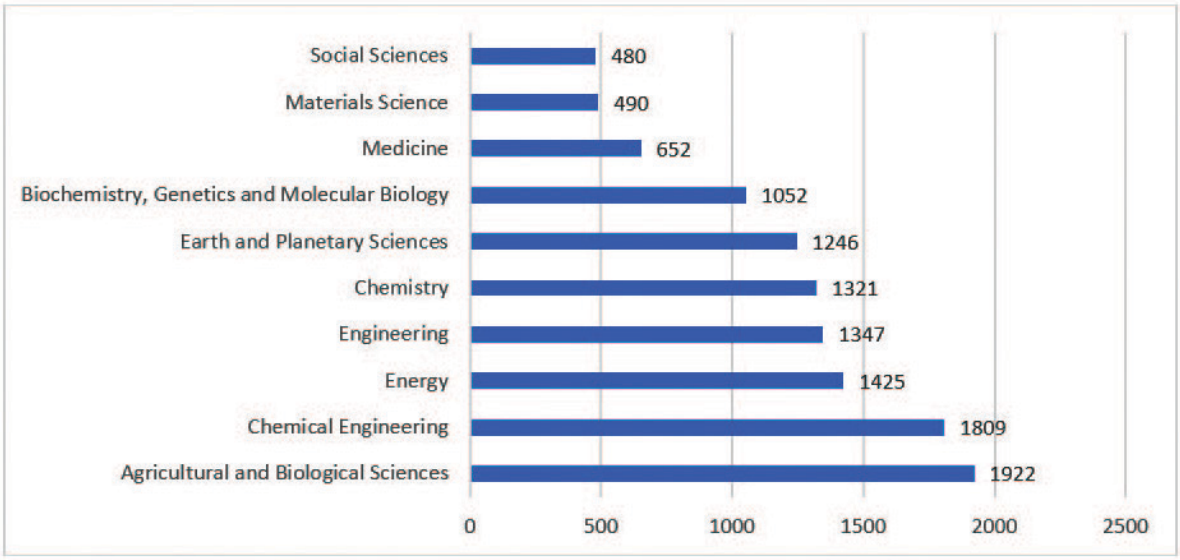

Figure 4. Top 10 collaborating subjects with the environmental science research in India funded by DST.

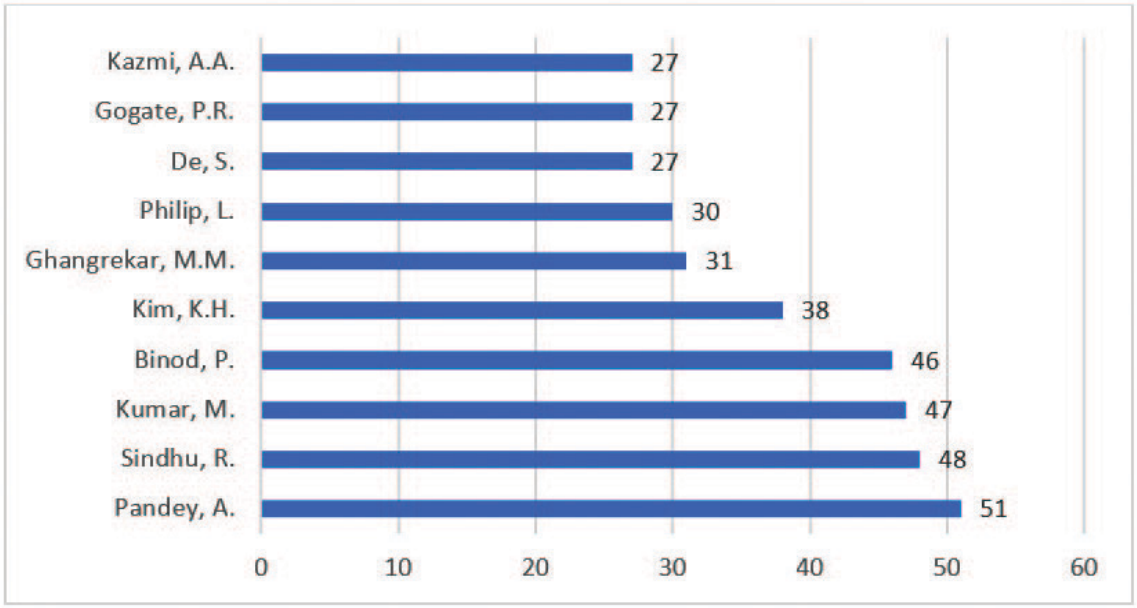

Figure 5. Top 10 authors of environmental science research in India funded by DST.

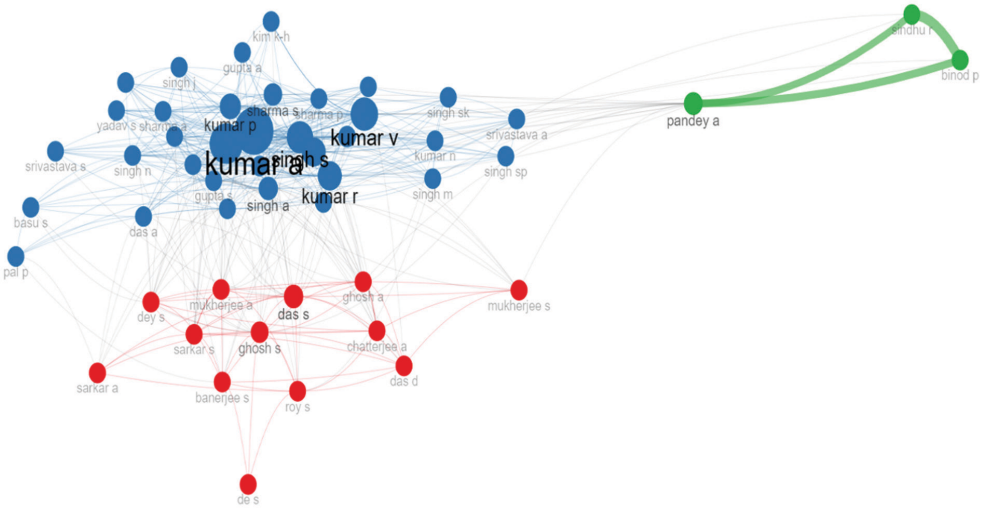

Figure 6. Collaboration network of the authors of environmental science research in India funded by DST.

second and third objectives of the study were to find the leading authors, organisations, countries and to study further their collaboration patterns. The study examined co-authorship and social structures using the biblioshiny package in R Studio.

6.2.1 Leading Authors of DST-funded Indian Environmental Science Research

Based on a number of publications the ten leading authors are depicted in Figure 5. Pandey, A. with 51 publications is the top contributing author, followed by Sindhu, R. (48); Kumar, M. (47); and Binod, P. (46).

The authors' collaboration network is displayed in Figure 6. The analysis's findings indicate that the most well-known authors in the field are Kumar, A; Kumar, V, and Kumar, M. These authors have strong networks of collaborations, while the other authors shown in the analysis have only modest networks. For instance, Kumar, A has strong relationships with numerous other authors, including Kumar, M; Sing, J; Yadav, S; Gupta, A and so on.

6.2.2 Leading Organisations of DST-funded Indian Environmental Science Research

The most prolific institutions in this particular field of study are depicted in Figure 7. The "Indian Institute of Technology, Delhi", with 290 documents, and the "Indian Institute of Technology, Kharagpur" with 292 documents are the next two research output leaders after the "Academy of Scientific and Innovation Research" contributing overall 416 documents.

Figure 8 illustrates the collaboration network between the affiliations, demonstrating how universities such as IIT, ACSIR, and NIT have developed extensive networks of cooperation with other academic institutions. As an illustration, we can observe that IIT has collaborations with institutions such as Banaras Hindu University, Indian Institute of Science, NIT, Durgapur, and others.

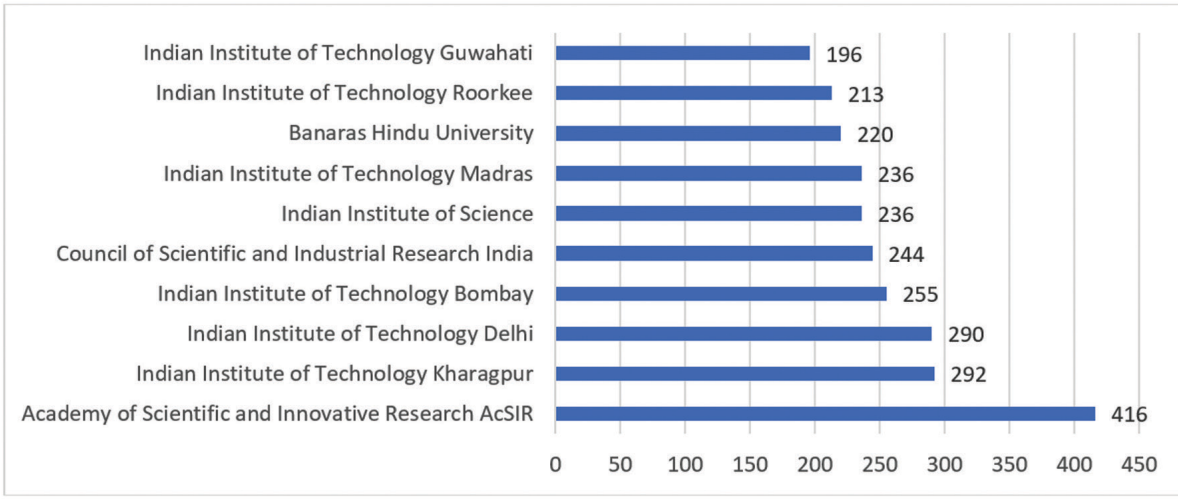

Figure 7. Top 10 institutions of environmental science research in India funded by DST.

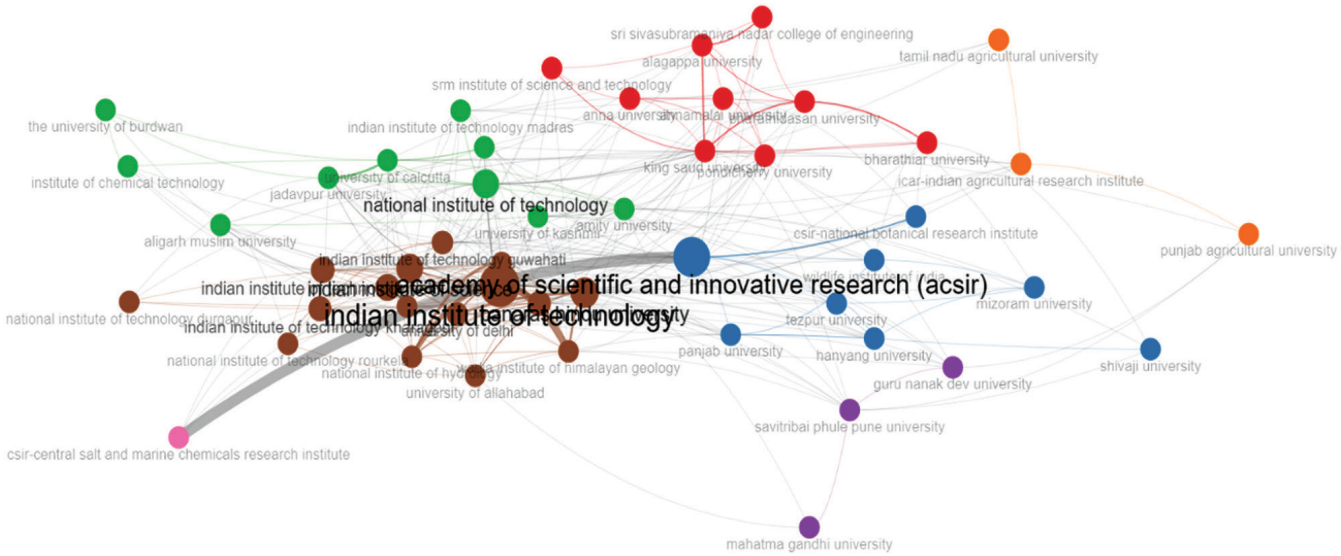

Figure 8. Collaboration network of the institutions of environmental science research in India funded by DST.

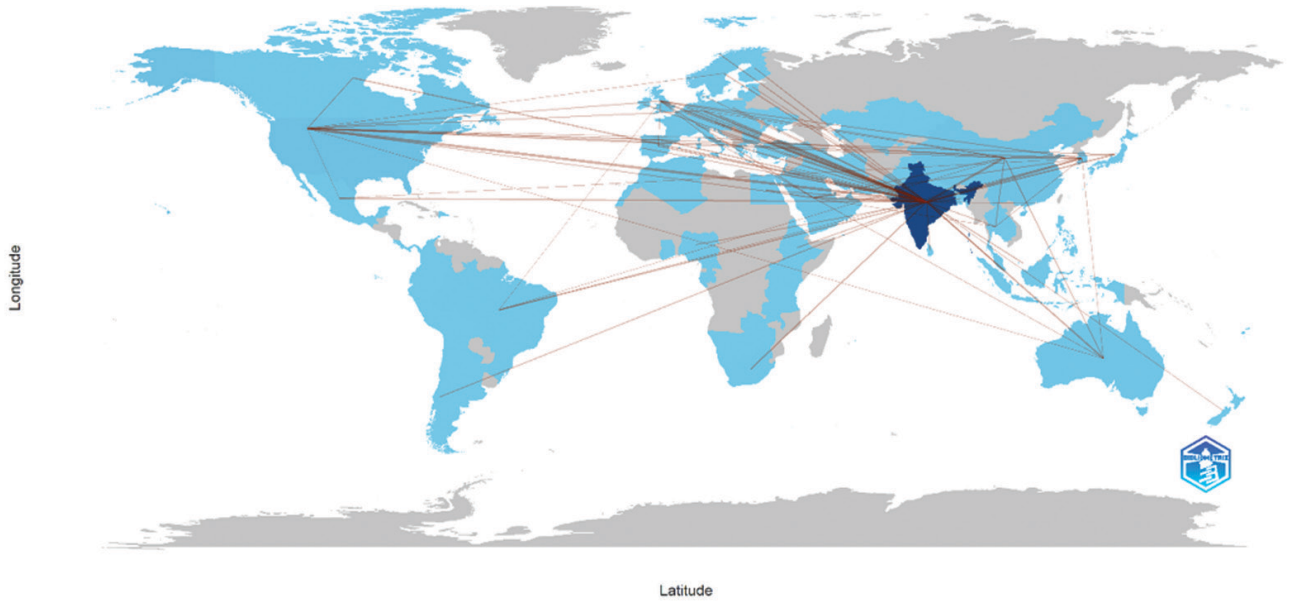

Figure 9. Collaborating network of the countries in environmental science research in India funded by DST.

6.2.3 Leading Collaborating Nations of DST-funded Indian Environmental Science Research

Table 2 and Figure 9 present the nations' collaboration with India in the DST-funded environmental science research. The United States is the most collaborative country, followed by China and Korea in second and third place.

Table 2. Top 10 collaborating countries with frequency of collaboration

From	To	Frequency
India	USA	439
India	Korea	298
India	China	279
India	United Kingdom	221
India	Saudi Arabia	195
India	Germany	149
India	Australia	130
India	Japan	108
India	Italy	75
India	Canada	73

Research on heavy metals, arsenic, and groundwater contamination presents interesting directions for the future. The upper left quadrant's niche theme highlights underrepresented subjects which are evolving quickly. The subjects of sustainability, biodiesel, and biomass are somewhat underrepresented here. The lower left quadrant's emerging or falling topic displays the themes that exhibit a negative or rising tendency over time. Terms with low centrality and density are found here, including photo catalysis, green synthesis, oxidative stress, antioxidants, climate change, and the Himalayas.

7. MAJOR FINDINGS

With the goal of offering an in-depth examination of environmental science research funded by the Department of Science and Technology (DST) of GOI, this study was intended to shed light on the contributions and achievements made in the field. Funds for authorised scientific projects in India are disbursed by the DST, which also acts as the main coordinating agency for national scientific activities and leads the promotion of new frontiers in science and technology[19].

Results of this study show that 2018 saw an acceleration of the growth rate starting in 2011. Between 2018 and

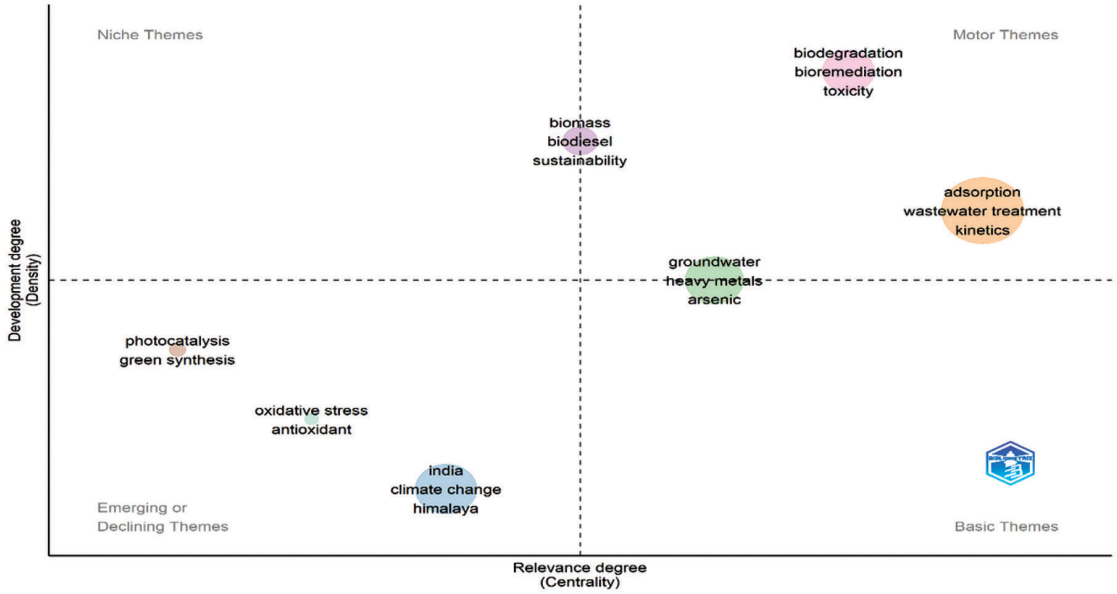

Figure 10. Thematic map.

6.3 Keyword Analysis

A thematic map that identifies four topological regions in the study area according to density and centrality sheds light on the linkages and spatial organisation of the area[18]. Figure 10 depicts the thematic map generated with the help of Biblioshiny from the keywords of the selected 8938 documents. Important driving themes like toxicity, adsorption, kinetics, biodegradation, and bioremediation are highlighted in the upper right quadrant. To solve environmental issues and advance sustainable practices, these concepts are essential. These fields of research have the potential to improve wastewater treatment processes and maximise remediation strategies.

2023, the number of publications rose at an incredibly quick pace. The preponderance of articles published in prestigious journals, especially "Environmental Science and Pollution Research" and "Bioresource Technology," highlights the academic vitality of the topic. These sources were also reported as the top sources in other research areas within environmental science[22]. Especially noteworthy are the extensive contributions made by writers such as Kumar, A., Kumar, V., and Kumar, M., as well as their networks of collaborations, which demonstrates the diverse range of scholarly activity in the field.

Another scientometric study also reported similar results, highlighting their significant impact[20]. Moreover, the

essential role played by institutes such as the "Academy of Scientific and Innovation Research", "Indian Institute of Technology, Delhi", and "Indian Institute of Technology, Kharagpur" in improving environmental science research is highlighted by their leadership in research output. Notably, these organisations were reported to be the top contributors in a scientometric study focused on Indian pollution control research outputs[21]. The collaborative landscape emphasises the significance of inter-institutional interaction in fostering research innovation, as demonstrated by network analysis. The thematic map also identifies important areas that show potential for tackling urgent environmental issues and promoting sustainable solutions, such as toxicity, biodegradation, and bioremediation. The primary research areas identified in this study differ from the findings of an scientometric investigation on environmental science research published by Indian academicians in open access environment[20].

8. CONCLUSION

This study demonstrates how environmental science research is dynamic and how important it is to do continued research and innovate to solve changing environmental challenges. Through the identification of new themes and trends, it offers significant advice for upcoming research activities that aim to effectively solve environmental concerns and promote sustainability. The results emphasise that in order to promote significant research outputs, the funding agencies, institutions, and researchers must continue to collaborate and support one another. Furthermore, by strategically allocating resources and prioritizing study topics, policymakers and stakeholders can use these insights to support sustainable environmental management and conservation efforts in India.

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His contributions to the current study are: Conceptualisation of ideas, research design, manuscript review, editing and supervision.