

Citation Behaviour of Researchers At Central Universities in the Western Himalayan Region of India



Muruli N^{1, 2}

¹Research Candidate, Department of Studies in Library and Information Science
University of Mysore, Mysuru
Karnataka -570006, India

²Assistant Professor, Department of Library and Information Science
Central University of Himachal Pradesh
Shahpur, Kangra, Himachal Pradesh - 176206, India
murulitarikere@hpcu.ac.in

N.S. Harinarayana
Professor, Department of Studies in Library and Information Science
University of Mysore, Manasagangothri, Mysuru
Karnataka -570006, India
harinarayana@lisc.uni-mysore.ac.in

ABSTRACT: This study presents a bibliometric analysis of citation behaviour among environmental science, chemistry, and physics researchers at Central Universities in India's Western Himalayan Region. The analysis is based on data extracted from the Scopus database, encompassing 53,180 references cited in research publications between 2012 and 2021 by researchers affiliated with central universities in the Western Himalayan Region. The study utilizes bibliometric techniques, including citation analysis, keyword analysis, and visualization tools using the 'Bibliometrix' and 'Biblioshiny' packages of R Studio. The study's objectives are to categorize cited sources, evaluate top journals and affiliations, explore research themes through keywords, and map interconnected topics via co-word analysis. Key findings include a predominance of journal articles (68.23%) and significant interdisciplinary collaborations. Discipline-specific journals like "Bioresource Technology" and "Physical Review Letters" are prominently cited. Keyword analysis highlights research emphases such as biodiversity and pollution in environmental science, materials science in chemistry, and astrophysics in physics.

Keywords: Citation Behaviour, Bibliometrics, Citation Analysis, Keyword Analysis, Central Universities, Western Himalayan Region, India, Scopus, Biblioshiny

Received: 3 July 2024, Revised 8 July 2024, Accepted 23 July 2024

DOI: <https://doi.org/10.6025/stm/2024/5/66-78>

1. Introduction

Research in bibliometrics is important for gaining insights into scientific communication and developing academic fields. By analysing citation characteristics, these studies offer a quantitative understanding of knowledge dissemination, identifying influential researchers, and clarifying scholarly networks. This information is valuable for research funding, policymaking, and curriculum development, ultimately enhancing the quality and impact of scientific research and fostering innovation (Donthu et al., 2021; Gyau et al., 2023; Leydesdorff & Vaughan, 2006; Mejia et al., 2021).

The Western Himalayan Region (WHR) of India, encompassing Jammu, Kashmir, Himachal Pradesh, and Uttarakhand, is

characterized by diverse geography, harsh climates, and rich biodiversity, presenting both opportunities and challenges for scientific exploration, particularly in fields such as environmental science, chemistry, and physics (Bandyopadhyay & Gyawali, 1994; Das & Meher, 2019; Kala, 2005; Tewari et al., 2017). This analysis focuses on the citation practices and priorities of researchers affiliated with central universities in the WHR. Using bibliometric techniques and citation analysis, the present study examines citation characteristics in research publications from scholars at the Central University of Himachal Pradesh (CUHP), Central University of Jammu (CUJ), Central University of Kashmir (CUK), and Hemvati Nandan Bahuguna Garhwal University (HNBGU), with a specific emphasis on the fields of environmental science, chemistry, and physics due to their significant contributions to understanding and addressing the region's unique environmental challenges.

Citing references is essential in acknowledging the ideas borrowed from previous works and serves as a vital resource for the academic community. In 1962, Garfield discussed the potential motivations behind authors citing other publications. Smith, in 1981, highlighted that analysing cited references can help validate hypotheses about information usage and compare user behaviour over time. Citation data aids in evaluating the impact of science and monitoring citation behaviour. Various analytic techniques, including citation analysis, are used in bibliometrics to assess the significance and influence of research across disciplines (Garfield, 1979). Citation analysis has attracted attention for evaluating the research landscape in developing countries like India. Citation behaviour refers to an author's choice of references based on the purpose of presenting information (Yang & Liu, 2022; Zhang et al., 2013). Rajani (2005) defines it as the sources used and the methods of citing, including contents, format, and data elements of citations. It encompasses the selection of sources, the positioning of citations within a work, and the amount of information included in each reference. Citation behaviour establishes the credibility of the author and their work by demonstrating thorough research and knowledge of existing literature. The current study seeks to analyze the citation behaviour of environmental science, chemistry, and physics researchers. The present research concentrates on how these scholars cite literature in their work through bibliometric methods and citation analysis. Understanding their citation behaviour can assist higher authorities in developing best practices and making informed decisions regarding university research policy.

2. Review of Literature

Understanding citation behaviour is essential for assessing scholarly communication and knowledge dissemination within academic circles. Citation practices vary across disciplines and geographical regions, influenced by factors such as research norms, publication trends, and institutional contexts (Moed, 2006). Bibliometric analyses provide systematic methods to quantify and analyze citation characteristics, including citation counts, identifying influential authors and journals, and mapping intellectual structures within disciplines (Aksnes, 2003). Liang and Rousseau (2010) highlighted the importance of using cited references in citation analysis to assess research impact, as they can reveal motivations behind citing specific work. Recent bibliometric studies have proven invaluable for evaluating research trends and impacts across various scientific disciplines (Liang et al., 2022) and also by analyzing keyword prevalence and co-occurrence, researchers gain a comprehensive understanding of the current state and potential future directions of the field (Nita, 2019).

A variety of methodologies have been employed by scholars to assess citation behaviour. Bornmann and Daniel (2008) provide a comprehensive evaluation of previous research on citation behaviour and frequency in determining scientific influence. Their study highlights the complexity of citation practices. Thornley et al. (2015) explored the role of trust and authority in citation behaviour through an interview-based study. They found that researchers regard the authority and trustworthiness of cited sources as crucial factors when selecting references, indicating that citation is at least partly an acknowledgement of the cited source's intellectual influence. The study also emphasized the importance of social networks and collaboration in shaping citation decisions, suggesting that the distinction between normative and constructionist theories of citation behaviour may not fully capture the nuanced relationship between these factors. In a study of the citation behaviour of Pondicherry University faculty, Singson et al. (2020) examined how faculty members navigate citation practices in a digital environment. Their findings indicate that while normative citation behaviour, focused on intellectual content, predominates, social constructivist behaviours also play a role. The study emphasizes the complexity of citation practices and the persistence of traditional trust criteria, even in the digital era.

Many researchers have evaluated references or sources cited by researchers at various universities, such as the University of Mysore and Karnatak University (Kodandarama & Chandrashekara, 2020) and Texas A&M University (Kimball et al., 2013). Muruli and Harinarayana (2024) specifically investigated the citation behaviour of physics researchers in the Western Himalayan Region, identifying the need for further evaluation of other researchers in the region. These studies provide insights into institutional citation behaviours and highlight the diversity of factors influencing reference selection.

3. Research Questions

This study aims to provide comprehensive insights into the citation behaviours among environmental science, chemistry, and physics researchers in the WHR of India, focusing on the following specific research questions:

RQ1 What types of sources are most frequently cited by researchers in environmental science, chemistry, and physics within the WHR?

RQ2 Which journals and academic affiliations are the most frequently cited in environmental science, chemistry, and physics research within the WHR?

RQ3 How do patterns of authorship and collaboration manifest among cited works in environmental science, chemistry, and physics research in the WHR?

RQ4 What are the top keywords and their frequency of occurrence that characterize environmental science, chemistry, and physics research in the WHR?

RQ5 How is research topics interconnected within environmental science, chemistry, and physics publications, as revealed by co-word analysis?

4. Methodology

4.1. Description Of Bibliometric Techniques Used

This study employs a comprehensive bibliometric analysis framework to investigate the citation practices and priorities of researchers in India's WHR. The methodology integrates bibliometric techniques, including citation analysis and keyword analysis, complemented by visualization such as word clouds and co-word network.

4.2 . Data Source and Sample Selection

The primary source of data for this study is the Scopus database. Scopus was chosen for its extensive coverage of peer-reviewed literature across a wide range of disciplines. This database is known for its high-quality records and is frequently used in bibliometric studies for its comprehensive indexing of articles, conference papers, and reviews (Elsevier, 2023). The study focuses on publications from four Central Universities in the WHR. These institutions were selected based on their significant contributions to research in the region.

The inclusion criteria for the publications were:

- **Time Frame:** Publications from the period 2012 to 2021 were analysed to capture the recent decade of research outputs.
- **Field of Study:** The focus was narrowed to environmental science, chemistry, and physics to maintain relevance to the study's aim.
- **Document Type:** Only 'articles' and 'reviews' were included to focus on substantial scholarly contributions.
- **Language Restrictions:** The search was restricted to English-language publications to maintain consistency in data analysis and interpretation.

4.3. Data Collection

To gather data, a structured search was conducted on Scopus using affiliation identifiers (CUHP-60107368; CUJ-60104778; CUK-60107398; HNBGU-60069550) for universities in the WHR. Scopus employs unique identifiers for each affiliation, enabling it to differentiate documents associated with specific institutions. The search was narrowed down by specified document types (articles and reviews) and publication years (2012 – 2021). A total of 53,180 citation data were obtained in CSV and BibTeX formats for further analysis.

4.4. Analysis of Data

For the data analysis, researchers utilized *R Studio* equipped with the Bibliometrix and Biblioshiny packages, selected for their specialized capabilities in bibliometric analysis (Aria & Cuccurullo, 2017). Bibliometrix was used for descriptive statistics, facilitating the analysis of document types, frequently cited sources, authors, affiliations, and countries. It supports various bibliometric methods and can import data from Scopus and other databases, constructing data matrices for co-citation and scientific collaboration analysis. Biblioshiny was employed for keyword mapping and network analysis, providing intuitive visualization tools for exploring bibliometric data and enhancing our understanding of research themes and scholarly networks within the WHR.

5. Data Analysis And Interpretations

5.1. Types Of Document Sources Cited By Researchers In The WHR

Analysing the types of documents cited by researchers in Table 1 offers valuable insights into their citation practices within

the WHR's central universities. Predominantly, researchers rely on '*articles*' as the primary document type across all central universities in the WHR, comprising 68.23% of total references. This strong preference for peer-reviewed journal articles emphasizes their key role as the mainstay of scholarly communication and evidence in environmental science, chemistry, and physics research. In contrast, citations of books, book chapters, and conference papers collectively constitute a smaller percentage, ranging from 0.28% to 2.07%, indicating a secondary but significant role in academic discourse. Notably, the category of 'undefined' document type accounts for 19.67% of all citations. This classification encompasses references lacking specific categorization or metadata, highlighting gaps in document-type information within citation databases like Scopus. Standardizing document classification practices across databases can improve the reliability and comprehensiveness of scholarly citation analyses in the field of bibliometrics and beyond. Overall, the data presented in Table 1 emphasizes the researcher's strong reliance on articles and calls for refinement in defining the metadata to enhance bibliographic data quality and reliability.

Table 1. Types of Document Sources Cited by Researchers in the WHR

S. N	Document Types	ENV		CHM		PHYS		GrandTotal	%
		NP	%	NP	%	NP	%		
1	Article	13937	59.84	12381	73.6	9969	76.30	36287	68.23
2	Book	63	0.27	49	0.29	38	0.29	150	0.28
3	Book Chapter	150	0.64	75	0.45	28	0.21	253	0.48
4	Conference Paper	405	1.74	315	1.87	382	2.92	1102	2.07
5	Data Paper	3	0.01	1	0.01	0	0.00	4	0.01
6	Editorial	36	0.15	29	0.17	12	0.09	77	0.14
7	Erratum	1	0.00	3	0.02	6	0.05	10	0.02
8	Letter	63	0.27	40	0.24	25	0.19	128	0.24
9	Note	58	0.25	32	0.19	12	0.09	102	0.19
10	Retracted	2	0.01	1	0.01	3	0.02	6	0.01
11	Review	1874	8.05	1774	10.55	790	6.05	4438	8.35
12	Short Survey	93	0.40	54	0.32	18	0.14	165	0.31
13	Undefined	6607	28.37	2069	12.3	1782	13.64	10458	19.67
	Total	23292	100	16823	100	13065	100	53180	100

5.2. Most Frequently Cited Journals by Researchers in the WHR

Examining the most cited journals provides valuable insights into the academic landscape and the impact of research on specific fields. It is important to note that the significance of a journal's citation frequency can vary based on factors such as the field of study, the nature of research, and the timeframe being considered. This study involved an analysis to rank the most frequently cited journals by researchers in environmental science, chemistry, and physics. Table 2 displays a ranked list of the top 5 journals in each subject area, presenting comprehensive information including each journal's rank, citation frequency, publisher, country, h-index, SJR Score, and Quartile Rank of the journal. This analysis illuminates the influential journals in these disciplines, reflecting their impact and the scholarly preferences within the WHR.

S.N	Source	Cited By	NP	Rank	Country	Publisher	h-index	SJR
1	Bioresource Technology	ENV	349	1	United Kingdom	Elsevier	364	2.58
2	Atmospheric Environment	ENV	250	2	United Kingdom	Elsevier	279	1.17
3	Science of the Total Environment	ENV	217	3	Netherlands	Elsevier	353	2
4	Environmental Science & Technology	ENV	213	4	United States	American Chemical Society	480	3.52
5	Chemosphere	ENV	207	5	United Kingdom	Elsevier	311	1.81
6	Journal of The American Chemical Society	CHM	345	1	USA	American Chemical Society	674	5.95
7	Organic Letters	CHM	231	2	USA	American Chemical Society	252	1.56
8	Angewandte Chemie—International Edition	CHM	212	3	UK	John Wiley and Sons Ltd	612	5.57
9	Journal of Organic Chemistry	CHM	203	4	USA	American Chemical Society	239	0.89
10	Chemical Reviews	CHM	201	5	USA	American Chemical Society	790	18.91
11	Physical Review Letters	PHY	333	1	United States	American Physical Society	647	3.25
12	Physical Review C - Nuclear Physics	PHY	234	2	United States	American Physical Society	221	1.32
13	Physical Review D - Particles, Fields, Gravitation and Cosmology	PHY	207	3	United States	American Physical Society	363	1.68
14	Astrophysical Journal	PHY	181	4	United States	American Astronomical Society	445	1.9
15	Applied Physics Letters	PHY	177	5	United States	American Institute of Physics	452	1.03

Note: Metrics of h-index, SJR, and Quartile are based on the Scimago Journal Rank

Table 2. Most Frequently Cited Journals by Researchers in the WHR

5.3. Most Cited Affiliations by Researchers in the WHR

The analysis of the top 10 affiliations (Table 3) cited by researchers in the WHR reveals a diverse and influential network of institutions contributing to the advancement of scientific research. The University of California consistently emerges as the leading affiliation across all three disciplines, highlighting its important role and extensive impact on global research. Asian institutions, such as Mae Fah Luang University, Chiang Mai University, the National University of Singapore, and the University of Tokyo, demonstrate significant contributions, reflecting the growing influence of Asian academia in the WHR research landscape. Indian institutions, including Banaras Hindu University and the Indian Institutes of Technology, are prominently cited, emphasizing their critical roles in fostering scientific research and innovation in the region. Prestigious institutes such as the Kunming Institute of Botany, Jawaharlal Nehru University, Oregon State University, King Saud University, and the Wadia Institute of Himalayan Geology are also key players, indicating a widespread collaborative effort across various geographic regions. These leading institutions serve as hubs of research excellence, attracting skilled researchers and fostering environments conducive to ground-breaking work. The diverse affiliations cited reflect a dynamic and interconnected global research community, driving forward the frontiers of knowledge in environmental science, chemistry, and physics within the WHR.

S.N	ENV	CHM			PHY	
	Affiliation	NP	Affiliation	NP	Affiliation	NP
1	University of California	472	University of California	368	University of California	456
2	Mae Fah Luang University	226	National University of Singapore	195	University of Tokyo	181
3	Chiang Mai University	162	Islamic Azad University	125	Tsinghua University	132
4	Banaras Hindu University	160	Indian Institute of Technology	114	Pennsylvania State University	130
5	Indian Institute of Technology	157	Nanyang Technological University	104	Indian Institute of Technology	122
6	Kunming Institute of Botany	147	Northwestern University	104	Massachusetts Institute of Technology	119
7	Jawaharlal Nehru University	140	Peking University	99	University of Tennessee	114
8	Oregon State University	132	University of Michigan	99	Peking University	110
9	King Saud University	127	Tsinghua University	97	Stanford University	109
10	Wadia Institute of Himalayan Geology	119	Sichuan University	90	Tohoku University	107

Table 3. Top 10 Affiliations Cited by Researchers in the WHR

5.4. Authorship Patterns in the Sources Cited by Researchers in the WHR

The study examines authorship patterns in the sources cited by environmental science, chemistry, and physics researchers across four Central Universities in the WHR. The study categorizes authorship patterns into eleven groups based on the number of authors, aiming to assess the distribution of single authorship, multiple authors (2 to 10 Authors), and More than 10 Authors across various document types. Table 4 provides a detailed analysis of these patterns, presenting the percentage distribution across different document types.

Environmental Science: Single-authored sources constitute 19.76% of all citations, indicating a significant reliance on individual contributions. However, multi-authored publications, particularly those with two authors (20.52%), are also prominently cited, suggesting a balanced preference for collaborative and individual research outputs.

Chemistry: Similar to Environmental Science, Chemistry shows a preference for multi-authored publications, with three authors leading at 17.78% and two authors at 16.37%. Single-authored sources are less dominant here (9.40%), indicating a higher reliance on collaborative research efforts compared to individual contributions.

Physics: In Physics, there is a notable preference for single-authored works (13.92%), followed closely by two-authored publications (18.95%), three (17.84%), and four (14.01%) authored publications. This suggests a balanced approach to citing both individual and collaborative research in the discipline.

More than 10 Authors: Publications with more than 10 authors are cited across all disciplines but represent a smaller percentage of citations: 2.67% in Environmental Science, 3.10% in Chemistry, and 5.69% in Physics. This indicates occasional engagement in extensive collaborative research efforts across these fields.

These findings provide valuable insights into how researchers in Environmental Science, Chemistry, and Physics within the

WHR cite literature, highlighting the balance between single-authored and multi-authored publications. The data emphasizes the collaborative nature of research in these disciplines while also recognizing the importance of individual contributions.

No of Authors	ENV							CHM							PHY							Grand	%
	A	B	C	R	O	Total	%	A	B	C	R	O	Total	%	A	B	C	R	O	Total	%	Total	
1	1025	68	70	279	3161	4603	19.76	526	33	39	213	770	1581	9.4	877	24	37	101	779	1818	13.92	8002	15.05
2	2530	69	73	460	1647	4779	20.52	1703	46	51	449	505	2754	16.37	1791	24	57	170	434	2476	18.95	10009	18.82
3	2758	35	83	356	950	4182	17.95	2125	22	68	415	361	2991	17.78	1775	7	79	179	291	2331	17.84	9504	17.87
4	2322	19	72	280	511	3204	13.76	2132	11	55	291	230	2719	16.16	1485	6	67	127	146	1831	14.01	7754	14.58
5	1765	7	48	171	255	2246	9.64	1783	4	50	148	144	2129	12.66	1113	2	47	76	85	1323	10.13	5698	10.71
6	1263	4	25	115	142	1549	6.65	1425	5	23	107	93	1653	9.83	807	1	29	46	48	931	7.13	4133	7.77
7	719	2	15	72	65	873	3.75	911	0	9	57	39	1016	6.04	603	0	16	31	31	681	5.21	2570	4.83
8	545	1	9	38	52	645	2.77	633	1	3	31	32	700	4.16	414	1	12	15	18	460	3.52	1805	3.39
9	314	2	3	24	15	358	1.54	434	1	6	28	11	480	2.85	251	0	6	16	9	282	2.16	1120	2.11
10	182	1	2	19	28	232	1	251	0	1	8	18	278	1.65	178	0	0	5	6	189	1.45	699	1.31
More than 10	514	5	5	60	37	621	2.67	458	1	10	27	26	522	3.1	675	1	32	24	11	743	5.69	1886	3.55
Total	13937	213	405	1874	6863	23292	100	12381	124	315	1774	2229	16823	100	9969	66	382	790	1858	13065	100	53180	100

Note: A-Article, B-Books & Book Chapters, C- Conference Papers, R-Reviews, O-Other Types.

Table 4. Authorship Patterns in the Sources Cited by Researchers in the WHR

5.5. Analysis of Top Keywords in the Sources Cited by Researchers in the WHR

5.5.1 Top Keywords of Environmental Science Sources

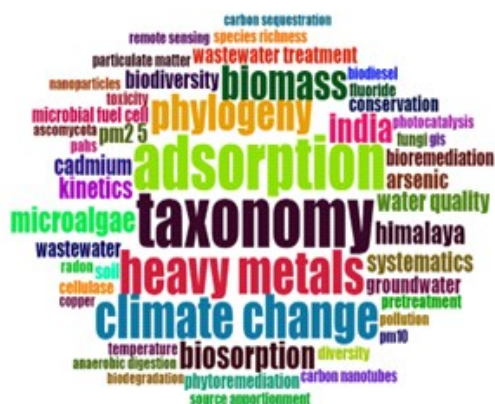


Figure 1. Word Cloud of Top 50 Author Keywords - Environmental Science

Figure 1 shows the top 50 “Author Keywords” found in the sources cited by environmental science researchers in the WHR in Word Cloud format. The importance of various terms reflects the diverse research areas and environmental concerns in this field. Larger and bolder words in the cloud, such as “taxonomy,” “adsorption,” “heavy metals,” “climate change,” and “phylogeny,” indicate their higher prevalence in the cited sources. The prominence of “taxonomy” and “phylogeny” suggests a significant emphasis on biological classification and evolutionary relationships among species. Additionally, “adsorption” and “heavy metals” feature prominently, reflecting a focus on environmental processes like adsorption phenomena and concerns regarding heavy metal pollution in the region’s ecosystems. “Climate change” emerges as a critical area of study, highlighting the researchers’ attention to the environmental impact of climatic variations in the WHR. The inclusion of terms like “biosorption,” “biomass,” “biodiversity,” and “bioremediation” emphasizes a strong interest in ecological solutions and sustainable approaches for addressing environmental issues.

Moreover, specific contaminants such as “cadmium,” “arsenic,” “fluoride,” “PAHs” (polycyclic aromatic hydrocarbons), and “radon” indicate a focus on studying various pollutants and their effects on the region’s environmental health. Additionally, technology-related terms like “microbial fuel cell,” “carbon nanotubes,” “nanoparticles,” and “remote sensing” hint at the incorporation of advanced techniques and innovative solutions in environmental research within the WHR. Overall, this word cloud provides a snapshot of the diverse research areas and environmental concerns that researchers in the WHR are exploring. It showcases a multidisciplinary approach involving ecological studies, pollution assessment, technological innovations, and environmental conservation efforts in this unique geographical area.

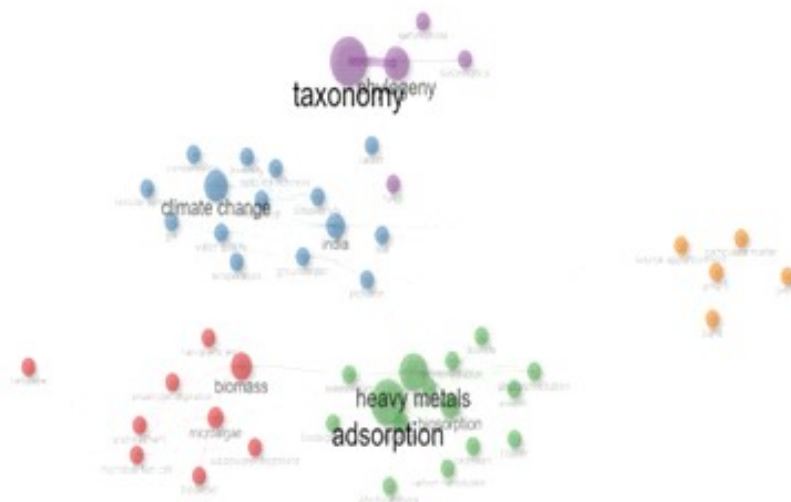


Figure 2. Co-Word Network of Author Keywords - Environmental Science

The Co-Word Network (Figure 2) is based on “Author Keywords” found in the sources cited by environmental science researchers in the WHR. It illustrates clusters of keywords and their relationships, offering insights into prevalent research themes and associations between concepts. In this network, individual keywords are represented as nodes, while related keywords are categorized into clusters based on their co-occurrence and thematic similarities.

Cluster 1 - Environmental Techniques and Processes: This cluster focuses on a variety of environmental techniques, treatment processes, and alternative energy sources, with keywords such as “biomass,” “microalgae,” “wastewater treatment,” “microbial fuel cell,” “pretreatment,” “cellulase,” “biodiesel,” “anaerobic digestion,” and “nanoparticles.”

Cluster 2 - Environmental Factors and Ecosystems: This cluster encompasses keywords related to environmental factors and ecosystems, including “climate change,” “India,” “Himalaya,” “water quality,” “biodiversity,” “groundwater,” “conservation,” “soil,” “diversity,” “radon,” “temperature,” “pollution,” “species richness,” “GIS,” and “remote sensing.”

Cluster 3 - Pollution and Remediation: This cluster primarily relates to pollution and remediation strategies, with keywords like “adsorption,” “heavy metals,” “biosorption,” “kinetics,” “cadmium,” “arsenic,” “wastewater,” “bioremediation,” “phytoremediation,” “fluoride,” “toxicity,” “photocatalysis,” “carbon nanotubes,” “copper,” and “biodegradation.”

Cluster 4 - Taxonomy and Biological Classification: This cluster revolves around taxonomy and biological classification, including keywords like “taxonomy,” “phylogeny,” “systematics,” “fungi,” and “ascomycota.”

Cluster 5—Air Quality and Pollutants: This cluster focuses on air quality, particulate matter, and pollutant sources, using keywords such as “PM2.5,” “PAHs,” “particulate matter,” “source apportionment,” and “PM10.”

The network analysis indicates that the research landscape within the Western Himalayan Region’s environmental science domain encompasses diverse areas, including environmental techniques, ecosystem studies, pollution, remediation strategies, taxonomy, and air quality assessment. These clusters demonstrate the multidisciplinary nature of research in environmental science, emphasizing the interconnectedness of different environmental concepts and methodologies.

5.5.2. Top Keywords of Chemistry Sources



Figure 3. Word Cloud of Top 50 Author Keywords - Chemistry

Figure 3 presents a word cloud of the top 50 author keywords found in the sources cited by Chemistry researchers. The word cloud highlights several prominent author keywords that reflect the key areas of research interest within Chemistry. Some of the notable author keywords include “adsorption,” “graphene,” “nanoparticles,” “palladium,” and “graphene oxide.” These keywords suggest that researchers in chemistry have been actively studying topics related to adsorption processes, the properties and applications of graphene and graphene oxide materials, and the synthesis and characterization of nanoparticles.

Other significant author keywords include “heterocycles,” “antioxidant,” “fluoride,” “synthesis,” and “kinetics.” These keywords point to areas of research focused on the study of heterocyclic compounds, the investigation of antioxidants and their activities, the behaviour and effects of fluoride, synthesis methodologies, and the kinetics of chemical reactions. Figure 3

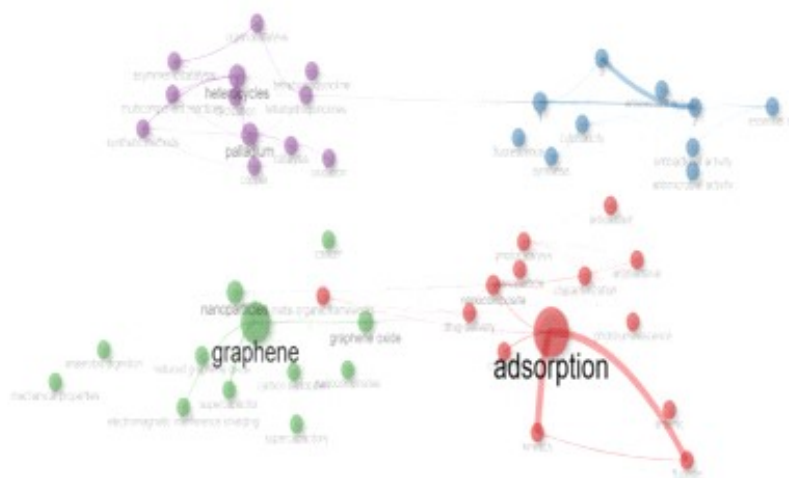


Figure 4. Co-Word Network of Author Keywords - Chemistry

also reveals author keywords related to specific applications and areas of study, such as “drug delivery,” “supercapacitor,” “cancer,” “photocatalysis,” and “antimicrobial activity.” These keywords indicate that Chemistry researchers have been engaged in research involving drug delivery systems, energy storage devices like supercapacitors, cancer-related studies, photocatalytic processes, and investigations into antimicrobial properties.

Based on author keywords, the co-word network analysis presented in Figure 4 provides insights into the connections between various research topics in chemistry. The network consists of several clusters, each representing a different set of keywords frequently used together in research articles. Cluster 1 includes keywords such as “adsorption,” “nanocomposite,” “drug delivery,” and “photocatalysis.” Cluster 2 includes keywords like “synthesis,” “essential oil,” “fluorescence,” and “cytotoxicity.” Cluster 3 focuses on keywords like “graphene,” “nanoparticles,” and “carbon nanotubes.” The strong associations and connections between keywords within these clusters indicate close relationships in the research literature.

5.5.3. Top Keywords of Physics Sources



Figure 5. Word Cloud of Top 50 Author Keywords – Physics

Figure 5 represents the most frequently mentioned author keywords in the sources cited by Physics researchers in WHR. Among the top 50 author keywords, “graphene” stands out as the most cited, emphasizing significant interest in this versatile material within the Physics community. The keyword “galaxies: active” follows closely, emphasizing research on active galaxies and their properties. Other notable keywords include “nanofluid”, “quasars: general”, and “graphene oxide”, highlighting their importance in physical and astronomical research. Keywords related to materials and their properties are also prominent, such as “adsorption”, indicating studies on surface interactions.

In addition, terms like “nanoparticles” and “nanocomposite” refer to nanoscale materials and their applications. Keywords such as “gas sensor”, “supercapacitor”, and “metal-organic frameworks” demonstrate interest in applied research and technological development in the field. These findings provide a valuable overview of keywords cited by physicists and astronomers, reflecting current research trends and focal areas. The visualization serves as an invaluable reference for scientists and researchers seeking to understand fundamental topics and research directions in Physics.

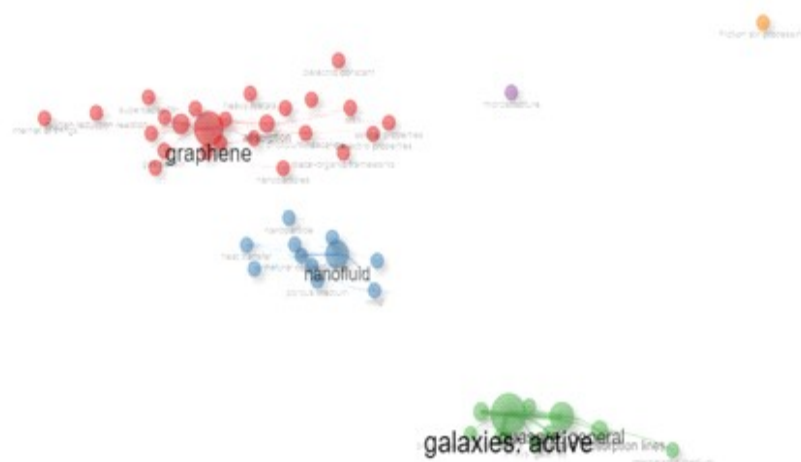


Figure 6. Co-Word Network of Author Keywords – Physics

Figure 6 presents a co-word network analysis based on “Author Keywords” in the citations by Physics researchers in the WHR. This analysis illustrates the interconnections and thematic clusters within the research community. It identifies several important nodes within the network, each representing a significant research topic or technology, organized into distinct clusters based on thematic similarity and interconnectedness.

Cluster 1 primarily revolves around materials science and nanotechnology themes, with “graphene” at its core. It demonstrates the highest betweenness centrality, closeness, and PageRank scores, indicating its central role and influence within the network. This cluster also covers related topics such as “graphene oxide,” “adsorption,” and “nanoparticles,” highlighting the focus on advanced materials and their applications, such as in “gas sensors” and “supercapacitors.”

Cluster 2 focuses on fluid dynamics and heat transfer, featuring “nanofluid” and “mhd” (magnetohydrodynamics). This cluster reflects the community’s interest in the thermal properties and applications of nanofluids and the effects of magnetic fields on fluid flow. It also encompasses studies on “natural convection” and “heat transfer,” showcasing a strong emphasis on understanding and optimizing energy transfer processes in various media.

Cluster 3 centers on astrophysics and cosmology, with “galaxies: active” serving as a significant node, linked to studies on “quasars: general,” “quasars: absorption lines,” and “galaxies: jets.” This cluster indicates a vibrant research interest in the dynamics and characteristics of galaxies and quasars, covering topics from the activity at galactic centers to the properties of jets and absorption lines in quasar spectra.

Overall, the network analysis charts the landscape of Physics research in the Western Himalayan Region and also highlights the interconnected nature of scientific inquiry, where advancements in one area, such as materials science, can have implications and applications in entirely different fields, such as energy systems or astrophysics.

6. Findings and Conclusion

The findings of this study highlight several significant aspects of citation practices and priorities among researchers in India’s WHR. Key findings include:

Citation Practices and Document Sources: The analysis revealed that journal articles constitute the majority of cited documents (68.23%) among researchers in environmental science, chemistry, and physics within the WHR. This highlights the predominant reliance on peer-reviewed literature for scholarly communication.

Influence of Journals and Disciplinary Trends: Discipline-specific journals play a crucial role in the citation practices of researchers in the WHR. Journals such as “Bioresource Technology,” “Journal of the American Chemical Society,” and

“Physical Review Letters” are prominently cited, reflecting disciplinary preferences and the engagement of regional researchers with impactful scientific publications.

Authorship Patterns and Collaborative Research: Single-authored papers are less common in Physics (13.92%) compared to Environmental Science (19.76%) and Chemistry (18.82%), indicating varying disciplinary norms or research practices. Conversely, multi-authored papers demonstrate high levels of collaboration across all disciplines, emphasizing the importance of collaborative research efforts in advancing scientific knowledge within the WHR.

Research Priorities and Keyword Analysis: Keyword analysis identified distinct research priorities across Environmental Science, Chemistry, and Physics. Environmental Science research focuses on biodiversity conservation, pollution control (e.g., “heavy metals”), and climate change impacts (“climate change”). Chemistry emphasizes materials science and synthesis technologies (e.g., “graphene,” “nanoparticles”), while Physics explores astrophysics (“galaxies: active”), nanofluid dynamics, and advanced materials (“graphene”).

Institutional Affiliations and Global Collaboration: Prominent institutional affiliations such as the University of California, Mae Fah Luang University, and Indian Institute of Technologies reflect both global collaboration and regional academic leadership in scientific research within the WHR. These affiliations facilitate knowledge exchange, resource sharing, and collaborative research initiatives, enhancing the region’s integration into global scientific networks. Such collaborations enrich research outcomes and also strengthen institutional capacities and promote cross-cultural understanding in scientific endeavours.

Implications for Policy and Future Research: Understanding citation practices and research priorities in Environmental Science, Chemistry, and Physics within the WHR provides valuable insights for policymakers, funding agencies, and academic institutions. These insights can guide strategic investments in research infrastructure, interdisciplinary collaborations, and capacity-building initiatives tailored to regional needs. Improving metadata standards, enhancing interdisciplinary research frameworks, and fostering international partnerships are crucial for advancing scientific knowledge, addressing societal challenges, and promoting sustainable development in the WHR.

In conclusion, the study on citation behaviour of researchers in Environmental Science, Chemistry, and Physics within the WHR provides valuable insights into scholarly communication and research trends. Key findings indicate a strong reliance on peer-reviewed journal articles, significant contributions from books and conference papers, and a need for improved document categorization practices. Collaborative research is prevalent across disciplines, emphasizing the interdisciplinary nature of scientific inquiry in the WHR. The prominence of specific journals, keywords, and affiliations reflects the region’s diverse research landscape and global connectivity in advancing knowledge in Environmental Science, Chemistry, and Physics. Future research should focus on refining bibliometric methodologies, enhancing database categorization practices, and exploring emerging research areas identified through keyword analysis. These efforts will further enrich understanding and collaboration within the scientific community, driving innovation and sustainable development in the WHR.

References

- [1] Aksnes, D. W. (2003). Characteristics of highly cited papers. *Research Evaluation*, 12(3), 159–170. <https://doi.org/10.3152/147154403781776645>
- [2] Aria, M., Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959–975. <https://doi.org/10.1016/j.joi.2017.08.007>
- [3] Bandyopadhyay, J., yawali, D. (1994). Himalayan water resources: Ecological and political aspects of management. *Mountain Research and Development*, 14(1), 1–24. <https://doi.org/10.2307/3673735>
- [4] Bornmann, L., Daniel, H. (2008). What do citation counts measure? A review of studies on citing behaviour. *Journal of Documentation*, 64(1), 45–80. <https://doi.org/10.1108/00220410810844150>
- [5] Das, L., Meher, J. K. (2019). Drivers of climate over the Western Himalayan region of India: A review. *Earth-Science Reviews*, 198, 102935. <https://doi.org/10.1016/j.earscirev.2019.102935>
- [6] Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- [7] Elsevier, E. (2023). *About Scopus—Abstract and citation database*. Scopus. <https://www.elsevier.com/solutions/scopus>

- [8] Garfield, E. (1962). Can citation indexing be automated. In *Statistical Association Methods for Mechanized Documentation*, 269, 189–192. https://scholar.google.com/scholar_lookup?title=Can%20citation%20indexing%20be%20automated&publication_year=1962&author=E.%20Garfield
- [9] Garfield, E. (1979). *Citation Indexing—Its Theory and Application in Science, Technology, and Humanities*. Wiley.
- [10] Gyau, E. B., Sakuwuda, K., & Asimeng, E. (2023). A Comprehensive Bibliometric Analysis and Visualization of Publications on Environmental Innovation. *Journal of Scientometric Research*, 12(3), Article 3. <https://doi.org/10.5530/jscires.12.3.052>
- [11] Kala, C. P. (2005). Indigenous Uses, Population Density, and Conservation of Threatened Medicinal Plants in Protected Areas of the Indian Himalayas. *Conservation Biology*, 19(2), 368–378. <https://doi.org/10.1111/j.1523-1739.2005.00602.x>
- [12] Kimball, R., Stephens, J., Hubbard, D., & Pickett, C. (2013). A citation analysis of Atmospheric science publications by faculty at Texas A&M university. *College & Research Libraries*, 74(4). <https://doi.org/10.5860/crl-351>
- [13] Kodandarama, & Chandrashekara, M. (2020). A citation analysis of chemistry publications by faculty members and research scholars at University of Mysore and Karnatak University. *Library Philosophy and Practice (e-Journal)*. <https://digitalcommons.unl.edu/libphilprac/4553>
- [14] Leydesdorff, L., & Vaughan, L. (2006). Co-occurrence matrices and their applications in information science: Extending ACA to the Web environment. *Journal of the American Society for Information Science and Technology*, 57(12), 1616–1628. <https://doi.org/10.1002/asi.20335>
- [15] Liang, J., Yin, Z., Yang, J., Li, Y., Xu, M., Li, J., Yang, M., & Niu, L. (2022). Bibliometrics and visualization analysis of research in the field of sustainable development of the blue economy (2006–2021). *Frontiers in Marine Science*, 9. <https://www.frontiersin.org/articles/10.3389/fmars.2022.936612>
- [16] Liang, L., & Rousseau, R. (2010). Reference analysis: A view in mirror of citation analysis. *Wuhan Daxue Xuebao (Xinxi Kexue Ban)/Geomatics and Information Science of Wuhan University*, 35.
- [17] Mejia, C., Wu, M., Zhang, Y., & Kajikawa, Y. (2021). Exploring Topics in Bibliometric Research Through Citation Networks and Semantic Analysis. *Frontiers in Research Metrics and Analytics*, 6. <https://www.frontiersin.org/articles/10.3389/frma.2021.742311>
- [18] Moed, H. F. (2006). *Citation Analysis in Research Evaluation*. Springer Science & Business Media.
- [19] N, M., Harinarayana, N. S. (2024). Citation Behaviour of Physics and Astronomy Researchers in the Western Himalayan Region. *DESIDOC Journal of Library & Information Technology*, 44(2), 87–93. <https://doi.org/10.14429/djlit.44.2.19265>
- [20] Nita, A. (2019). Empowering impact assessments knowledge and international research collaboration—A bibliometric analysis of Environmental Impact Assessment Review journal. *Environmental Impact Assessment Review*, 78, 106283. <https://doi.org/10.1016/j.eiar.2019.106283>
- [21] Rajani, R. (2005). *Research approach and citation behaviour in english literature* [University of Kerala]. <http://shodhganga.inflibnet.ac.in:8080/jspui/handle/10603/70748>
- [22] Singson, M., Sunny, S. K., Thiyagarajan, S., & Dkhar, V. (2020). Citation behavior of Pondicherry University faculty in digital environment: A survey. *Global Knowledge, Memory and Communication*, 69(4/5), 363–375. <https://doi.org/10.1108/GKMC-07-2019-0084>
- [23] Smith, L. C. (1981). Citation analysis. *Library Trends*, 30(1), 83–106.
- [24] Tewari, V. P., Verma, R. K., & von Gadow, K. (2017). Climate change effects in the Western Himalayan ecosystems of India: Evidence and strategies. *Forest Ecosystems*, 4(1), 13. <https://doi.org/10.1186/s40663-017-0100-4>
- [25] Thornley, C., Watkinson, A., Nicholas, D., Volentine, R., & Jamali, H. R. (2015). The role of trust and authority in the citation behaviour of researchers. *Information Research*, 20(3). https://trace.tennessee.edu/utk_infoscierepubs/157/
- [26] Yang, J., Liu, Z. (2022). The effect of citation behaviour on knowledge diffusion and intellectual structure. *Journal of Informetrics*, 16(1), 101225. <https://doi.org/10.1016/j.joi.2021.101225>
- [27] Zhang, G., Ding, Y., Milojevic, S. (2013). Citation content analysis (CCA): A framework for syntactic and semantic analysis of citation content. *Journal of the American Society for Information Science and Technology*, 64(7), 1490–1503. <https://doi.org/10.1002/asi.22850>