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Original Research Article

Scientometric study on vibration energy and harvesting research productivity (2015 to 2024): Analysing trends and implications

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Abstract

This scientometric study investigates global research productivity and trends in Vibration Energy and Harvesting from 2015 to 2024, comprehensively analysing the field's growth, collaboration patterns, and academic impact. The study provides insightful analysis by drawing on bibliometric data from 3,900 publications indexed across 965 sources and identifies an annual growth rate of 2.01% and an average of 15.56 citations per document. The dataset includes diverse document types, with journal articles (2,601) and conference papers (1,102) contributing significantly. An analysis of keywords reveals 6,485 author-defined keywords and 12,646 enhanced terms through co-occurrence analysis. Collaborative research emerges as a defining field feature, with an average of 4.25 co-authors per document and 20.08% international co-authorship. Multi-authored works dominate the output, while single-authored documents account for only 2.43% of total publications. Using visualisation tools like VOSviewer, researchers evaluated research trends, facilitating the exploration of co-occurrence and citation metrics. This study highlights key trends, including a steady rise in scholarly activity, robust international collaborations, and significant contributions from highly cited research. These findings offer valuable insights into the dynamic progression of Vibration Energy and Harvesting research, emphasising its growing impact and the importance of collaborative, multidisciplinary approaches.

Keywords: Vibration energy harvesting, Scientometric analysis, Research productivity, Collaboration, Bibliometrics.

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1. Introduction

Vibration energy and Harvesting is a transformative technology that converts mechanical vibrations into electrical energy, playing a crucial role in powering small devices and sensors in various industries such as aerospace and automotive. (Harne & Wang, 2013; Mitcheson et al., 2008). This process often utilises piezoelectric materials, which generate an electric charge in response to mechanical stress, thus enhancing energy conversion efficiency. (Erturk et al., 2011; Kim et al., 2011). Energy harvesting systems, including those focused on vibrations, capture ambient energy from the environment, providing a sustainable alternative to traditional batteries. (Shaikh & Zeadally, 2016). Vibration sensors are crucial in optimising these systems by detecting and measuring vibrations, ensuring effective energy conversion.

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Additionally, micro-electromechanical systems are commonly employed in vibration energy and harvesters due to their compact size and high efficiency, further advancing the field of energy harvesting. (Fan et al., 2012). Together, these components create a robust framework for harnessing vibration energy effectively.

Moreover, integrating advanced materials and innovative designs is paving the way for more efficient Vibration Energy and Harvesting systems. For instance, researchers are exploring triboelectric nanogenerators, which can effectively capture energy from a broader range of vibrational frequencies compared to traditional piezoelectric devices. (Wu et al., 2019). This adaptability enhances energy conversion efficiency and opens new applications in environments where vibrations vary widely, such as urban infrastructure or industrial machinery. Additionally, these technologies have the potential to be embedded within structures, allowing for real-time mechanical health monitoring, further emphasising their role in energy generation and structural integrity assessment. As we refine these systems, the synergy between energy harvesting and smart technology will likely drive significant advancements in sustainable energy solutions.

2. Literature Review

The field of Vibration Energy and Harvesting has witnessed substantial advancements, with numerous studies exploring methods to convert mechanical vibrations into electrical power. Piezoelectric and electromagnetic transduction methods are extensively used along with other methods for energy harvesting with linear or nonlinear mechanisms (Malaji & Ali, 2018; Hu et al., 2021; Huang et al., 2022; Wang et al., 2023; Kattimani et al., 2024; Rajarathinam et al., 2024; Zhang et al., 2025; Zhao et al., 2025). This literature review consolidates key research contributions in bibliometric studies and presents a comprehensive analysis of various energy harvesting mechanisms, with a primary focus on bistable systems, piezoelectric devices, electromagnetic generators, and triboelectric generators. The scientometric analysis of Vibration Energy and Harvesting research production from 2015 to 2024 offers significant insights into the development of this sector and its ramifications for future research and technical advancements.

The comprehensive bibliometric analysis conducted by Al-Quaishi focuses on Vibration Energy and Harvesting research from 2005 to 2022, revealing China and the United States as leading contributors. The study emphasises integrating machine learning and artificial intelligence to enhance Vibration Energy and Harvesting device efficiency, providing valuable insights, identifying research frontiers, and suggesting critical sub-domains for future exploration (Al-Quaishi et al., 2024). Alias and Rahman conducted a comprehensive bibliometric analysis on energy harvesting from Vortex-Induced Vibration, emphasising its potential for renewable energy generation through innovative technologies. The study highlights increasing research activity in this field, identifies key contributors, and explores emerging focus areas (Alias & Rahman, 2024). Syifaul Fuada and others conducted a bibliometric analysis on the trends and global growth of energy harvesting for implantable medical devices (IMDs), emphasising the potential for EH technology to extend battery life and reduce the weight of IMDs. The study identifies a continuous increase in EH research for infectious and parasitic diseases, with the United States and the University of Bern leading in contributions. (Syifaul Fuada et al., 2024)

Sarker and others conducted a comprehensive bibliometric analysis on low-cost Piezoelectric Micro-Energy Harvesting (PMEH) systems from ambient energy sources. The study explores current trends, issues, and suggestions in the field, aiming to provide insights into PMEH applications, authors' contributions, collaboration networks, and research areas. The research identifies key challenges and recommends enhancing PMEH to improve energy efficiency and operational performance (Sarker et al., 2022). Hamidah and others conducted a bibliometric analysis of Micro Electro Mechanical System (MEMS) energy harvester research, highlighting its significant contributions to sustainable energy development. The study utilized VOSviewer software to analyze publication distributions, authors, affiliations, HCPs, keywords, and their relationships, aiming to map out the research progress in MEMS for energy harvesting. The analysis identified key research topics, China as a leading contributor, and potential future issues to address in MEMS energy harvester research, providing valuable insights and guidance for future advancements in the field (Hamidah et al., 2021). Jiang and others conducted a bibliometric study exploring the evolution and prospects of implantable energy harvesters (IEHs) and self-powered implantable medical electronics (SIMEs) over 25 years. The study highlights the significance of implantable nanogenerator research and the promising potential for clinical applications of SIMEs (Jiang et al., 2020). Wu and others on triboelectric nanogenerators outline their foundational role in powering micro/nano devices and self-powered sensors (Wu et al., 2019). Kim and others along with Shaikh & Zeadally further expand on the applications of piezoelectric energy harvesting in wireless sensor networks (WSNs), identifying challenges and proposing future directions for developing efficient energy harvesting systems (Kim et al., 2011) and (Shaikh & Zeadally, 2016). Harne and Wang provided a detailed review of bistable electromechanical dynamics, presenting a common analytical framework and summarising significant results and challenges in the design of bistable energy harvesters (Harne & Wang, 2013). Fan and others demonstrate the efficacy of TEGs in converting mechanical energy into electrical power, emphasising their applications in self-powered systems (Fan et al., 2012). Erturk and others delve into piezoelectric transduction, providing analytical solutions for unimorph and bimorph configurations under various load conditions (Erturk et al., 2011). Mitcheson and others highlighted the potential of ambient motion as an energy source, discussing state-of-the-art motion-driven miniature harvesters and their applications (Mitcheson et al., 2008). Ottman and others introduced an adaptive control technique for optimising power transfer in piezoelectric devices, demonstrating a significant increase in power transfer efficiency (Ottman et al., 2002). Zhongyu Hu and others conducted a bibliometric study on “A Comprehensive Review of Acoustic based Leak Localization method in Pressurized Pipelines” results disclosed that, 197 publications, with 2019 marking the peak of scholarly contributions, reflecting intensified advancements in detection methodologies. Furthermore, a co-authorship analysis found that, 20 active researches out of 160, with Brennan’s lab emerging as the most productive contributor, appearing in multiple key publications. Moreover, seven of the ten most cited papers were linked to authors within this cluster, reinforcing the impact of collaborative research efforts. It is understood from the study that, correlation-based detection technologies have emerged as the most widely applied approach in leak localization, leveraging acoustic principles to enhance accuracy (Hu et al., 2021).

3. Materials and Methods

Vibration Energy and Harvesting publications retrieved from the Scopus international database (https://www.scopus.com) using a defined search approach. Researchers searched for the keywords "Vibration", "Energy", and "Harvesting" in the "Title" or key tags, and they limited the search output to the period from 2015 to 2024 using the data range tag. The search string was as follows (Vibration* Energy and Harvesting*) and PUBYEAR >2015 to <2024 as shown in the PRISMA flow diagram (**Figure 1**) (Haddaway et al., 2022).

Scopus's analytical provisions further analysed the research data on Vibration Energy and Harvesting. The counting method fully counted every contributing author or organisation in multiple-authorship publications. Researchers assessed the quality of publications by using indices such as h-index (HI), relative citation index (RCI), and citations per paper (CPP). Researchers divided the number of citations by the number of publications to obtain CPP. The RCI was calculated by dividing the number of publication citations by the average number of citations an article usually receives in the same field. The obtained number gets benchmarked to the median RCI for all NIH-FP. Scopus automated calculators obtained the H-index or Hirsch index and defined it as the maximum value of h in a way that an author or journal has published at least h papers, each of which has been cited at least h times. A publication was considered an HCP if it had received more than 100 citations. We also used the activity index to understand the gradual changes in research activity with time. Citations to the publications are counted from the article's publication until December 31, 2024.

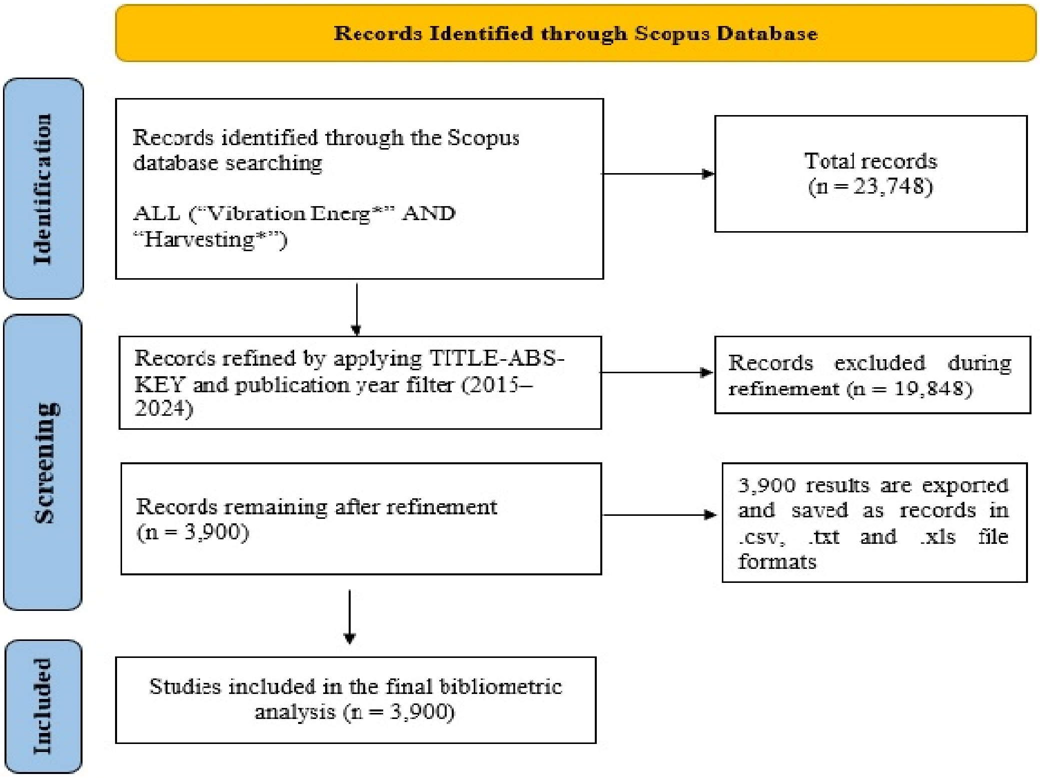

Figure 1: PRISMA flow diagram of Scopus data retrieval and refinement, Vibration Energy and Harvesting Research

4. Data Analysis and Interpretation

4.1. Publication growth

The year-wise performance of research publications, citation of papers, international collaborative papers, RCI, HCPs, and total cited papers is shown in **Table 1**. Ten years' data reveal that, in 2023, the most publications were produced on "Vibration Energy and Harvesting," followed by 2022 and 2019, respectively, but slightly dipped in the coronavirus period (2020). TC gradually increased from 2015 to 2017, but then they dropped drastically in the year 2015 to 2024 from 6438 to 458. Most citations were received in 2017, followed by 2019 and 2018. CPP increased from 18.88 in the year 2015 to 31.14 in the year 2017; then, it decreased to 1.12 in the year 2024.

Regarding funding, the highest funding is received in the year 2023, followed by 2022 and 2024. The maximum number of Total Cited Papers can be found in 2019 (n=363) and the lowest in 2024 (n=148). Funding for the papers increased from 108 in 2015 to 283 in 2024, but in 2022 and 2023, it increased to 305 and 332. The total number of publications cited increased gradually, whereas HCPs increased in 2017 but steadily decreased from 28 to 0 in 2023 and 2024. It indicates that HCPs will decrease in the coming years, but their funding will increase.

4.2. Types of documents with citations

The type of documents, their funding and citations, and CPP, ICP, HCP, and RCI results are displayed in **Table 2**. The research articles dominated the study by getting 67% (2601) publications, 76% of FP, and 83% of citations among the 3900 research papers. CPP is highest in reviews at about 67.32, which shows the researcher's interest in it, followed by articles and books, whereas conference papers, book chapters, editorials, letters and erratum are very few, respectively. Funded research involves 2218 publications. Overall, 57% of the publications received funding from various organisations. Articles have the highest international collaboration in the field of study; at the same time, it is known that Data papers and editorials of the journals have a high ICP. Under HCPs, articles accounted for 82% of the HCPs, whereas reviews accounted for 17.39%. Reviews have the highest 4.3 RCI compared to any other type of document during the study period, followed by article publication with 1.2.

Table 1: Year-wise performance of research on vibration energy and harvesting

Years	TP	TC	FP	CPP	NC	ICP	% ICP	RCI	HCP	TCP
2015	341	6438	108	18.88	56	67	19.65	1.2	10	285
2016	328	6370	117	19.42	40	82	25.00	1.2	7	288
2017	339	10558	171	31.14	36	66	19.47	2	28	303
2018	378	8618	225	22.80	44	77	20.37	1.5	15	334
2019	419	8758	240	20.90	56	97	23.15	1.3	14	363
2020	322	6001	182	18.64	34	76	23.60	1.2	8	288
2021	417	6097	255	14.62	56	108	25.90	0.9	6	361
2022	465	4862	305	10.46	93	90	19.35	0.7	4	372
2023	483	2528	332	5.23	138	92	19.05	0.3	0	345
2024	408	458	283	1.12	259	95	23.28	0.1	0	148
Total	**3900**	**60688**	**2218**	**15.56**	**812**	**850**	**21.79**	**1.0**	**92**	**3087**

TP: Total Publications, TC: Total Citations, CPP: Papers, FP: Funded Papers, ICP: International Collaborative Papers, RCI: Relative Citation Index, HCP: Highly Cited Papers, TCP: Total Cited Papers

Table 2: Document-wise research performance on vibration energy and harvesting

Document Type	TP	FA	TC	CPP	ICP	% ICP	HCP	RCI
Article	2601	1680	50192	19.29	598	23.00	75	1.2
Conference paper	1129	467	3713	3.29	194	17.60	1	0.2
Review	95	61	6396	67.32	31	32.60	16	4.3
Book chapter	53	4	170	3.2	18	34.00	0	0.2
Book	9	0	160	17.77	4	44.40	0	1.1
Editorial	4	2	12	3	4	100.00	0	0.2
Erratum	3	0	5	1.66	0	0.00	0	0.1
Letter	3	2	9	3	0	0.00	0	0.2
Data paper	1	1	11	11	1	100.00	0	0.7
Note	1	1	2	2	0	0.00	0	0.1
Short survey	1	0	18	18	0	0.00	0	1.2
Total	3900	2218	60688	15.56	850	21.79	92	1.00

4.3. Most productive countries

From **Table 3,** China emerged as the primary collaborator, contributing 41.66% (n=1850) share of the joint publications in this domain among the top twenty-five countries during the 2015-2024 period, followed by countries like the US and UK published ¼ (n=502) of China's publications and ½ (n=224) of United States publications were published by the United Kingdom, these two countries are having 11.30% (n=502) and 5.04% (n=224) collaboration with other countries respectively. In terms of citation impact, here also all the first three positions went to China, the United States and the United Kingdom by receiving 53.38% (n=32397), 22.26% (n=13513) and 9.38% (n=5658) citations, respectively. Among the top twenty-five countries, these publications' average number of citations is 3269.

Italy and Turkey became leaders with 99.84 and 91.78 CPP, followed by Poland with 84.28, Brazil at 81.71, Japan at 81.58, the Czech Republic at 69.35 and Hong Kong at 44 CPP during the study period. These countries' CPP is more than the average CPP of the top twenty-five countries.

Figure 2 depicts the VOSviewer network visualisation map of the top 25 countries (which have 25 or more publications) in co-authorship with China on Vibration Energy and Harvesting research. The 25 countries were classified into five clusters, establishing 137 links with a TLS 869. Cluster 1 comprises 10 countries: The United States (22 links) and Japan (15 links) have the highest collaborations among the nine countries in this cluster. Cluster 2 consists of 7 countries: The United Kingdom (19 links) and India (16 links) lead the collaborations in this cluster. Cluster 3 includes four countries, while Cluster 4 comprises three countries: France and Germany, each with 12 links. Cluster 5 has one country, Hong Kong, with nine links. The visualisation shows that China, the US, the UK, India, and Japan were the most collaborative and productive countries, as illustrated using VOSviewer. Node size indicates the number of publications, while the thickness of the connecting lines represents the strength of co-authorship links. Clusters are colour-coded to show regional or thematic collaboration patterns.

Table 3: Leading contributing countries in vibration energy and harvesting research (2015-2024), highlighting total publications, citation metrics, international collaborations, and bibliometric indicators

Country	TP	TC	CPP	FP	HCP	RCI	TLS	Cluster	Links
China	1850	32397	17.51	1302	57	1.13	471	3	19
United States	502	13513	26.92	272	28	1.73	221	1	22
India	246	2505	10.18	71	4	0.65	47	2	16
Japan	234	1909	8.16	135	0	0.52	48	1	15
United Kingdom	224	5658	25.26	147	10	1.62	173	2	19
France	151	1953	12.93	1	55	0.83	64	4	12
South Korea	131	2783	21.24	91	5	1.37	39	1	11
Italy	125	1248	9.98	50	0	0.64	48	2	10
Germany	99	1254	12.67	50	0	0.81	59	4	12
Malaysia	98	994	10.14	51	2	0.65	32	1	9
Hong Kong	96	4224	44.00	78	12	2.83	94	5	9
Canada	91	1605	17.64	50	2	1.13	51	1	13
Australia	88	2916	33.14	37	7	2.13	57	3	13
Singapore	64	1883	29.42	43	5	1.89	64	3	10
Poland	56	472	8.43	32	0	0.54	29	2	10
New Zealand	53	1875	35.38	40	6	2.27	64	3	7
Taiwan	53	597	11.26	43	0	0.72	22	1	9
Iran	50	807	16.14	8	0	1.04	24	1	11
Ireland	45	784	17.42	31	1	1.12	32	2	10
Tunisia	36	372	10.33	9	0	0.66	34	4	4
Brazil	35	286	8.17	22	0	0.53	11	2	4
Czech Republic	31	215	6.94	19	0	0.45	5	2	4
Egypt	29	822	28.34	9	1	1.82	26	1	9
Turkey	28	257	9.18	10	0	0.59	10	1	6
Russian Federation	25	395	15.80	17	0	1.02	13	1	10

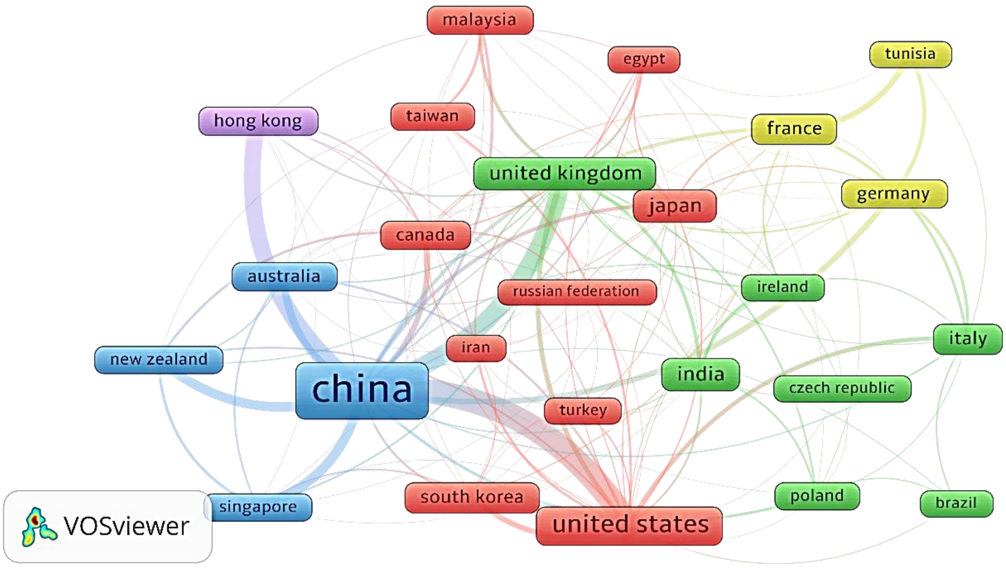

Figure 2: International collaboration network among the top 25 countries

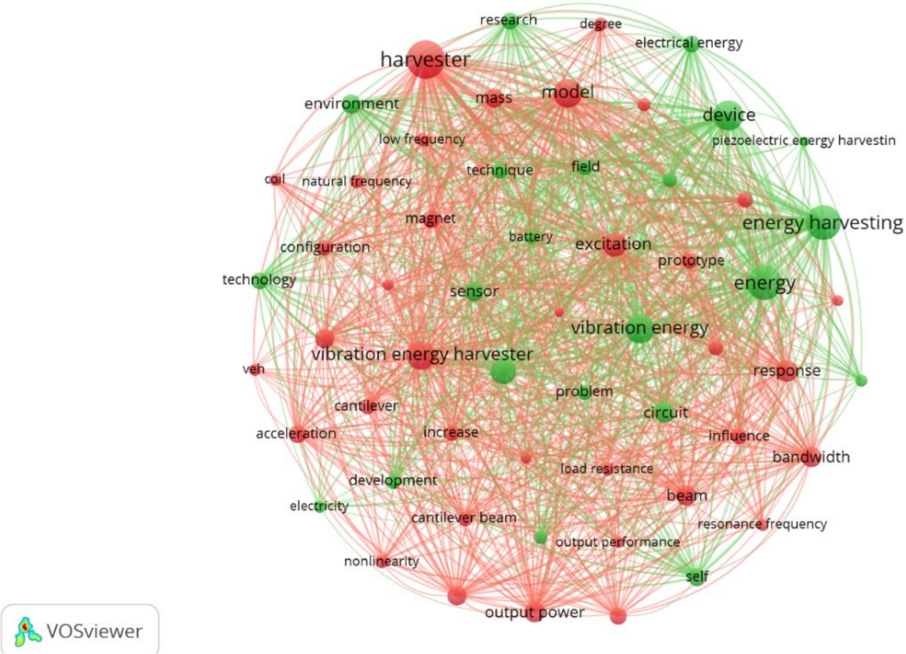

Figure 3: Keyword co-occurrence network

4.4. Significant keywords

Figure 3 represents the top 101 significant keywords in Vibrations Energy and harvesting research; this network is visualised as a neural network. In this network, different colours show different clusters. The figure below has only two clusters showing in red and green colours, and the thickness of the links between the keywords signifies the strength of their co-occurrence (occurring together at least 100 times). This analysis identified two key clusters, ranked by their importance. The red colour (Keyword: Harvesting) of cluster 1 has the highest number of 2190 keywords, followed by green colour (Keyword: Energy Harvesting) and (Keyword: Energy), which have 1848 and 1763 keywords, respectively. The size of each node indicates the frequency of keyword occurrence, while the thickness of the connecting lines represents the strength of co-occurrence. Different colours represent distinct thematic clusters within the research domain.

4.5. Most productive authors

Of the 8918 authors who contributed 3900 publications to Vibration Energy and harvesting research between 2015–2024. The top 25 most productive authors (with 21 or more papers) contributed 18.51% and 31.74% of the TP and TC, respectively (**Table 4**). These leading authors were primarily from China (12) and France (3), Hong Kong, the USA and the UK (2) and with one each from Japan, Poland, the Netherlands and New Zealand. TP range from 21 to 46, with Badel, Adrien being the most prolific author (46 papers), while Erturk, Alper and Wang, Zhong Lin report the lowest (21 papers each). TC span widely distributed from 54 to 2,831, with Wang, Zhong Lin receiving the highest number of citations, reflecting his substantial influence in the field. CPP metric ranges from 2.45 to an exceptional 134.81, again led by Wang, Zhong Lin, indicating the high quality and visibility of his publications. FP, an indicator of lead research contributions, vary from 7 to 35, with Jia, Yu topping the list. The number of HCPs ranges from 0 to 8, showing that only a few authors consistently produce high-impact research. RCI ranges from 0.16 to 8.66, further underscoring the outsized influence of Wang, Zhong Lin. In terms of collaboration, TLS varies from 0 to 56, with Seshia, Ashwin A and Jia, Yu having the most extensive co-authorship networks. Finally, co-authorship links range from 0 to 7, reflecting varying degrees of collaborative integration.

Table 4: Bibliometric details of the top 25 most productive authors in Vibration energy and harvesting research (2015–2024), highlighting their publication output, citation impact, and collaborative networks

Author	Affiliation	TP	TC	CPP	FP	HCP	RCI	TLS	Cluster	Links
Badel, Adrien	Université Savoie Mont Blanc, France	46	698	15.17	21	0	0.98	43	3	2
Du, Sijun	Delft University of Technology, Netherlands	28	704	25.14	27	1	1.62	51	4	3
Erturk, Alper	Georgia Institute of Technology, USA	21	689	32.81	12	4	2.11	1	2	1
Gibus, David	Université Savoie Mont Blanc, France	21	152	7.24	7	0	0.47	40	3	2
Hu, Guobiao	Hong Kong University of Science and Technology, Hong Kong	26	742	28.54	22	2	1.83	28	1	4
Jia, Yu	Aston University, UK	43	905	21.05	35	1	1.35	54	4	2
Liang, Junrui	ShanghaiTech University, China	22	421	19.14	12	1	1.23	13	1	5
Liao, Wei-Hsin	Chinese University of Hong Kong, Hong Kong	25	994	39.76	19	3	2.56	8	6	3
Litak, Grzegorz	Lublin University of Technology, Poland	25	268	10.72	17	0	0.69	3	2	1
Masuda, Arata	Kyoto Institute of Technology, Japan	22	54	2.45	9	0	0.16	0	7	0
Morel, Adrien	Université Savoie Mont Blanc, France	24	233	9.71	8	0	0.62	43	3	2
Qin, Weiyang	Northwestern Polytechnical University, China	38	753	19.82	33	2	1.27	9	1	4
Seshia, Ashwin A	University of Cambridge, UK	36	874	24.28	32	1	1.56	56	4	2
Shi, Ge	China Jiliang University, China	24	350	14.58	22	0	0.94	41	5	2
Tang, Lihua	University of Auckland, New Zealand	43	1731	40.26	34	6	2.59	31	1	5
Tao, Kai	Northwestern Polytechnical University, China	30	805	26.83	18	2	1.72	13	1	3
Thein, Chung Ket	University of Nottingham Ningbo, China	28	214	7.64	21	0	0.49	0	8	0
Wang, Guangqing	Zhejiang Gongshang University, China	26	347	13.35	9	1	0.86	5	6	1
Wang, Junlei	Zhengzhou University, China	24	1280	53.33	19	4	3.43	18	1	5
Wang, Zhong Lin	Chinese Academy of Sciences Beijing, China	21	2831	134.81	16	8	8.66	1	1	1
Xia, Huakang	Ningbo University, China	32	509	15.91	24	0	1.02	39	5	2
Xia, Yinshui	Ningbo University, China	22	318	14.45	20	0	0.93	40	5	2
Zhang, Zutao	Southwest Jiaotong University, China	28	562	20.07	26	1	1.29	0	9	0
Zhou, Shengxi	Northwestern Polytechnical University, China	26	1502	57.77	21	6	3.71	10	2	7
Zuo, Lei	University of Michigan, USA	41	1327	32.37	27	2	2.08	1	2	1

The analysis explored the co-authorship interactions among 8,918 authors, with a refined selection criterion resulting in 25 authors meeting the minimum threshold of 21 documents and 54 citations per author. This selective process produced nine distinct clusters interconnected by 30 links, with a TLS of 274. Cluster 1 comprises seven authors, followed by Cluster 2 with four authors, and Clusters 3 to 5, each consisting of three authors. Cluster 5 includes two authors, while Clusters 7 to 9 feature one author in each cluster, as elucidated in **Figure 4**. This network map offers a comprehensive visual representation of the collaborative landscape and research groups shaping the Vibration Energy and Harvesting research domain, illuminating key collaborative dynamics and influential author clusters within the field.

Author co-authorship network map in Vibration Energy and Harvesting research (2015–2024), visualised using VOSviewer. Each node in the network represents an author whose size indicates the number of publications or citations attributed to that author. The lines between nodes, known as edges, symbolise co-authorship links, and the thickness of these lines denotes the strength of collaboration between authors. Authors are grouped into distinct clusters based on their co-authorship relationships, distinguished by different colours, showcasing collaborative dynamics and research groupings within the domain.

4.6. Most productive organisation

Further**, Table 5** shows that 1885 organisations contributed to research on Vibration Energy and Harvesting. Among these, 1085 organisations contributed a single paper, while 669 contributed 2 - 10 papers each. The top 25 organisations individually contributed 1,542 papers and 40,981 citations, respectively. Notably, the top five organisations, such as Northwestern Polytechnical University, lead with 146 publications and 3,148 TC, reflecting their significant research output and impact. The institution's citation metrics, including CPP at 21.56 and RCI at 1.39, underline its scholarly influence. Additionally, Northwestern Polytechnical University's strong collaborative networks, as indicated by a TLS of 84 and clustering in Group 2 with 17 links, highlight its active engagement within the research community.

The Ministry of Education of the People's Republic of China demonstrates a notable research presence in Vibration Energy and Harvesting, with 139 publications and 3,662 TC. The institution's citation metrics, such as a Citations per Publication of 26.35 and an RCI of 1.69, reflect its research quality and impact within the field. Moreover, the Ministry of Education's high TLS of 128 and clustering in Group 6 with 18 links signify extensive collaborative efforts and knowledge dissemination activities.

Southwest Jiaotong University, Chongqing University, and Xi'an Jiaotong University also exhibit commendable research performance in Vibration Energy and Harvesting. With varying publication counts, citation metrics, and collaborative strengths, these institutions contribute significantly to the advancement of knowledge and innovation in the field.

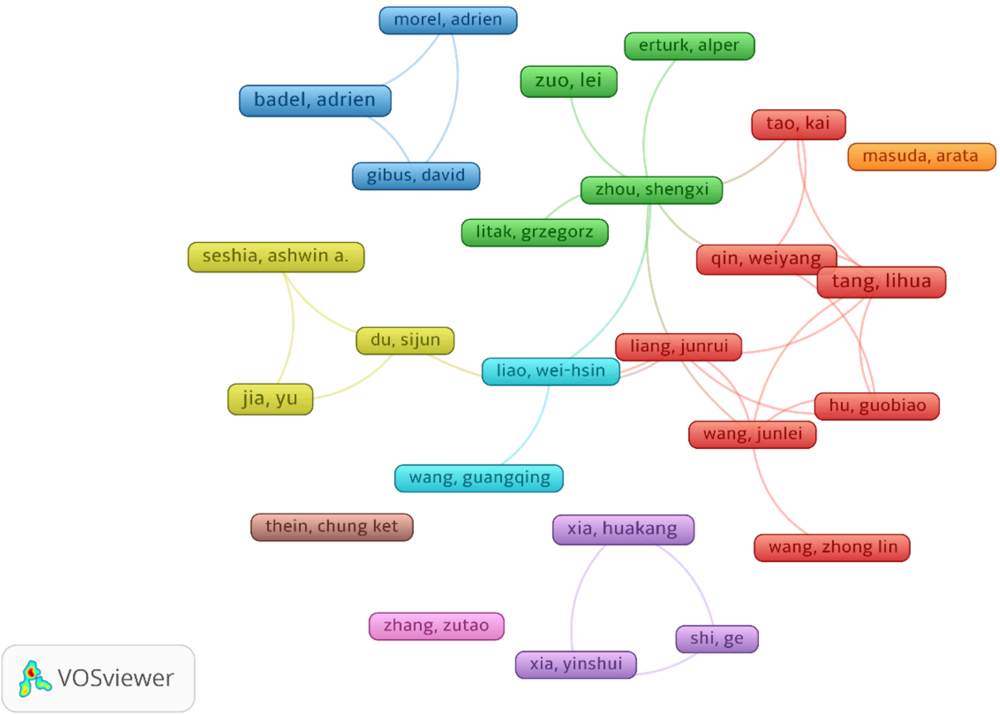

Figure 4: Visualisation of the Top 25 *Author co-authorship network map*

Table 5: Top 25 institutions contributing to vibration energy and harvesting research, ranked by publication count, with corresponding citation metrics, authorship details, and collaborative network indicators

Organization	TP	TC	CPP	FA	HCP	RCI	TLS	Cluster	Links
Northwestern Polytechnical University	146	3148	21.56	118	8	1.39	84	2	17
Ministry of Education of the People's Republic of China	139	3662	26.35	108	7	1.69	128	6	18
Southwest Jiaotong University	92	1969	21.40	73	3	1.38	59	6	14
Chongqing University	90	2049	22.77	73	2	1.46	43	6	11
Xi'an Jiaotong University	78	1655	21.22	65	2	1.36	34	2	10
Harbin Institute of Technology	68	1526	22.44	52	0	1.44	18	1	9
CNRS Centre National De La Recherche Scientifique	64	644	10.06	26	0	0.65	11	4	4
Shanghai Jiao Tong University	61	1370	22.46	47	3	1.44	21	2	12
Nanjing University of Aeronautics and Astronautics	58	1118	19.28	32	2	1.24	19	4	8
Zhejiang University	58	885	15.26	44	1	0.98	21	1	11
Virginia Tech	56	1813	32.38	41	4	2.08	5	2	4
Chinese Academy of Sciences, Beijing	53	3462	65.32	45	9	4.20	39	5	9
Tianjin University	53	683	12.89	34	1	0.83	12	1	7
Georgia Institute of Technology	50	3511	70.22	35	12	4.51	31	5	10
University of Auckland	50	1777	35.54	38	6	2.28	46	3	9
University Savoie Mont Blanc	46	714	15.52	23	0	1.00	12	4	3
Tohoku University	45	528	11.73	29	0	0.75	4	4	3
Hong Kong Polytechnic University	44	2752	62.55	39	8	4.02	25	1	11
Zhengzhou University	44	1481	33.66	42	4	2.16	29	3	11
Huazhong University of Science and Technology	43	929	21.60	27	2	1.39	13	3	5
Xidian University	42	746	17.76	38	0	1.14	27	5	10
Beijing University of Technology	42	714	17.00	35	1	1.09	10	1	4
University of Michigan	40	1730	43.25	18	4	2.78	14	2	4
Nanyang Technological University	40	1412	35.30	30	4	2.27	35	3	11
Shanghai University	40	703	17.58	35	3	1.13	16	1	9

Of the 1,885 organisations that possess a minimum of 40 papers and 501 citations, 25 meet the required thresholds, boasting 112 links and a TLS 378 as shown in **Figure 5**. These organisations are divided into six clusters: Cluster 1 comprises six organisations, Cluster 2 features five organisations, Cluster 3 and Cluster 4 contain four organisations each, while Cluster 5 and Cluster 6 have three organisations, and these clusters were generated using the VOSviewer tool.

4.7. Medium of research communication

The analysis of prolific journals in Vibration Energy and Harvesting sheds light on key trends and contributions within the scholarly domain. Out of 919 sources publishing research papers on this subject, the distribution showcases varying levels of publication output. Notably, one source stands out with 532 publications, accounting for 57.89% of the total, while the range of 2 to 10 sources contributes 325 publications (35.36%), and the range of 11 to 26 sources accounts for 37 publications (4.03%). This distribution highlights the concentration of publishing activity among few sources. A significant impact is observed among the top 25 sources, which represent 2.72% of the total sources. These sources collectively contributed 1,540 papers and generated 33,364 citations, translating to a substantial share of 39.49% of TP and 54.98% of TC in the field. Smart Materials and Structures emerges as a standout journal, publishing 170 papers on Vibration Energy, Mechanical Systems, and Signal Processing, receiving 4,742 citations, and featuring 100 FP with 12 HCPs.

Additionally, Applied Energy, with a noteworthy CPP of 57.03, has published 73 papers and received 4,163 citations, reflecting a RCI of 3.66. Energy conversion and management, despite publishing 62 papers, received 3,040 citations, showcasing a CPP of 49.03 and an RCI of 3.15. Nano energy stands out with the highest CiteScore of 30.3 (Q1) among the journals analyzed, while six journals boast an impact factor exceeding the average of 10.00. On the other end of the spectrum, Proceedings of SPIE - The International Society for Optical Engineering and Yadian Yu Shengguang/Piezoelectrics and Acoustooptics are identified as having the lowest impact factor in this study, as outlined in **Table 6**.

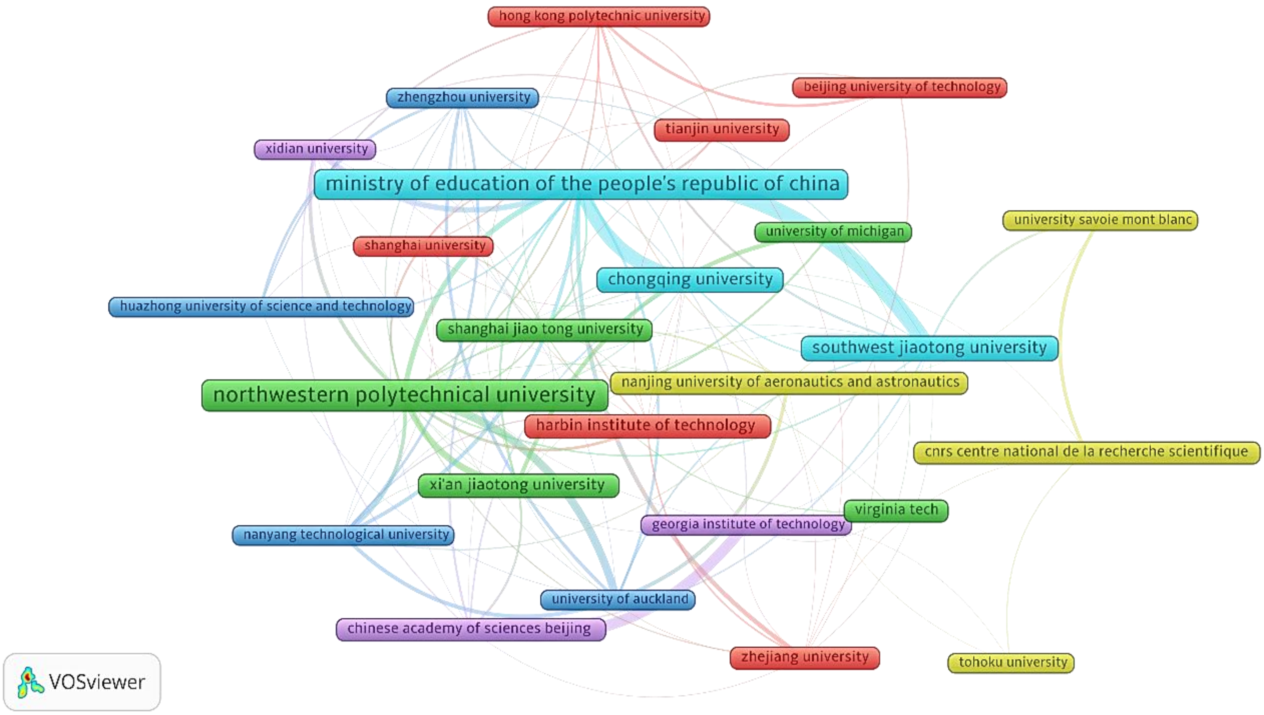

Figure 5: Visualisation of the top 25 organisations

Table 6: Core sources contributing to Vibration Energy and Harvesting research (2015–2024), detailing publication output, citation performance, journal metrics, and collaborative network parameters

Source	TP	TC	CPP	FA	HCP	RCI	CiteScore	Quartile	TLS	Cluster	Links
Smart Materials and Structures	170	4276	25.15	93	6	1.62	7.5	Q1	206	2	15
Mechanical Systems and Signal Processing	127	4742	37.34	100	12	2.40	14.8	Q1	408	2	23
Proceedings of SPIE - The International Society for Optical Engineering	127	362	2.85	42	0	0.18	0.5	Q4	57	3	10
Journal of Physics: Conference Series	113	397	3.51	42	0	0.23	1.2	Q3	17	3	8
Sensors and Actuators A: Physical	91	2014	22.13	77	0	1.42	8.1	Q1	277	3	22
Journal of Intelligent Material Systems and Structures	87	1417	16.29	52	1	1.05	5.4	Q1	264	2	20
Applied Energy	73	4163	57.03	68	10	3.66	21.2	Q1	357	1	23
Sensors	63	824	13.08	54	0	0.84	7.3	Q1	92	2	16
Energy Conversion and Management	62	3040	49.03	52	10	3.15	19.0	Q1	216	1	20
Nano Energy	58	2700	46.55	55	8	2.99	30.3	Q1	58	1	17
Energy	57	1578	27.68	50	3	1.78	15.3	Q1	123	5	19
Micromachines	56	616	11.00	45	0	0.71	5.2	Q2	118	1	13
Journal of Sound and Vibration	53	1838	34.68	40	4	2.23	9.1	Q1	209	4	22
Energies	46	386	8.39	36	0	0.54	6.2	Q1	89	4	14

Table 6 Continued….

Applied Physics Letters	39	1484	38.05	26	3	2.45	6.4	Q1	13	2	8
Nonlinear Dynamics	39	829	21.26	38	0	1.37	9.0	Q1	154	2	17
Microsystem Technologies	38	525	13.82	22	0	0.89	5.2	Q2	92	1	18
Yadian Yu Shengguang/Piezoelectrics and Acoustooptics	33	57	1.73	0	0	0.11	0.5	Q4	8	4	5
Journal of Vibration and Shock	32	125	3.91	0	0	0.25	1.6	Q3	27	4	11
International Journal of Mechanical Sciences	31	820	26.45	23	0	1.70	12.8	Q1	107	2	18
IEEE Sensors Journal	30	720	24.00	15	1	1.54	7.7	Q1	63	3	18
Applied Sciences (Switzerland)	30	361	12.03	23	0	0.77	5.3	Q1	53	1	12
Lecture Notes in Mechanical Engineering	30	13	0.43	12	0	0.03	0.9	Q4	6	1	4
Proceedings of the ASME Design Engineering Technical Conference	28	65	2.32	17	0	0.15	1.00	N/A	10	5	5
Lecture Notes in Electrical Engineering	27	12	0.44	11	0	0.03	0.7	Q4	6	1	4

Co-citation network map of the top 25 most cited sources in Vibration Energy and Harvesting research (2015–2024), generated using VOSviewer. In this network representation, each node corresponds to a source, be it a journal or a conference, with the node's size indicative of the number of citations received. The thickness of the interconnecting lines (edges) signifies the strength of the co-citation relationships between the sources. Moreover, varying colours assigned to nodes denote distinct clusters, implying thematic cohesion or disciplinary affinities among the sources.

Among the 919 sources analysed, 25 sources satisfy the established criteria of a minimum of 26 documents and 12 citations, delineated into five clusters characterised by 181 links and a TLS of 1515. Cluster 1 comprises eight sources, followed by Cluster 2 with seven sources, and Clusters 3 and 4, each consisting of 4 sources. Cluster 5 is composed of 2 sources. The layout formation of these clusters exhibits an attraction of 9 and a repulsion of -8, influencing the spatial arrangement of the nodes as illustrated in **Figure 6**. This visualisation encapsulates the interconnections and thematic relationships among sources in the Vibration Energy and Harvesting research domain, offering a comprehensive view of the scholarly network dynamics over the specified timeframe.

4.8. Citation overview of highly cited papers

The citation dynamics of the top 10 HCPs in the field of Vibration Energy and Harvesting between 2015 and 2024 demonstrate varied trajectories of academic influence, reflecting both immediate and sustained impacts within the scholarly community. Among the leading publications, the paper by (Chen & Wang, 2017) exhibited a consistently high citation growth, peaking in 2022 and 2023 with 149 citations each, before declining slightly in 2024. Similarly, (Wei & Jing, 2017) maintained a strong citation trajectory, reaching a maximum of 123 citations in 2022 and sustaining considerable academic attention through 2024. Safaei et al. (2019) showed a notable delayed impact, with citations surging significantly from 2020 onwards and peaking at 163 in 2022, indicating increasing recognition in recent years. Additionally, the work of You et al. (2019) experienced a sharp rise in citations in the most recent years, reflecting its emerging importance (**Figure 7**). Collectively, these patterns underscore both the temporal evolution and the sustained academic value of key contributions to vibration energy harvesting research, with several papers continuing to shape the discourse and research directions in the domain.

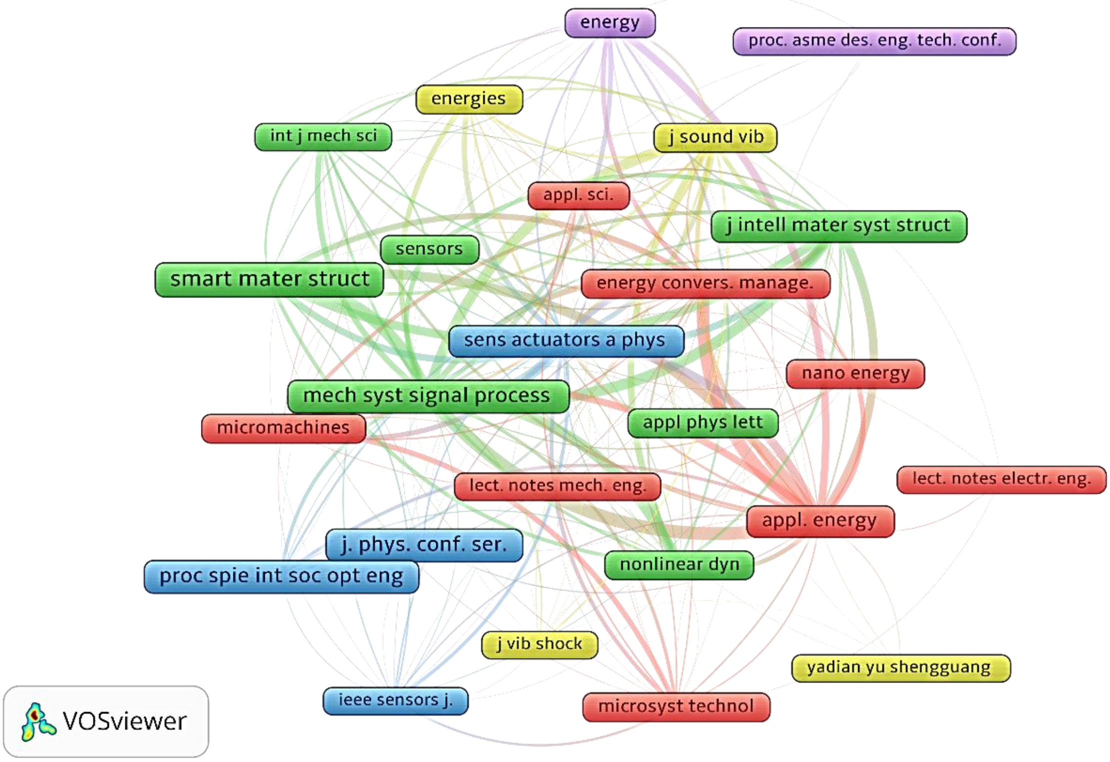

Figure 6: Co-citation network map of the top 25 most cited sources

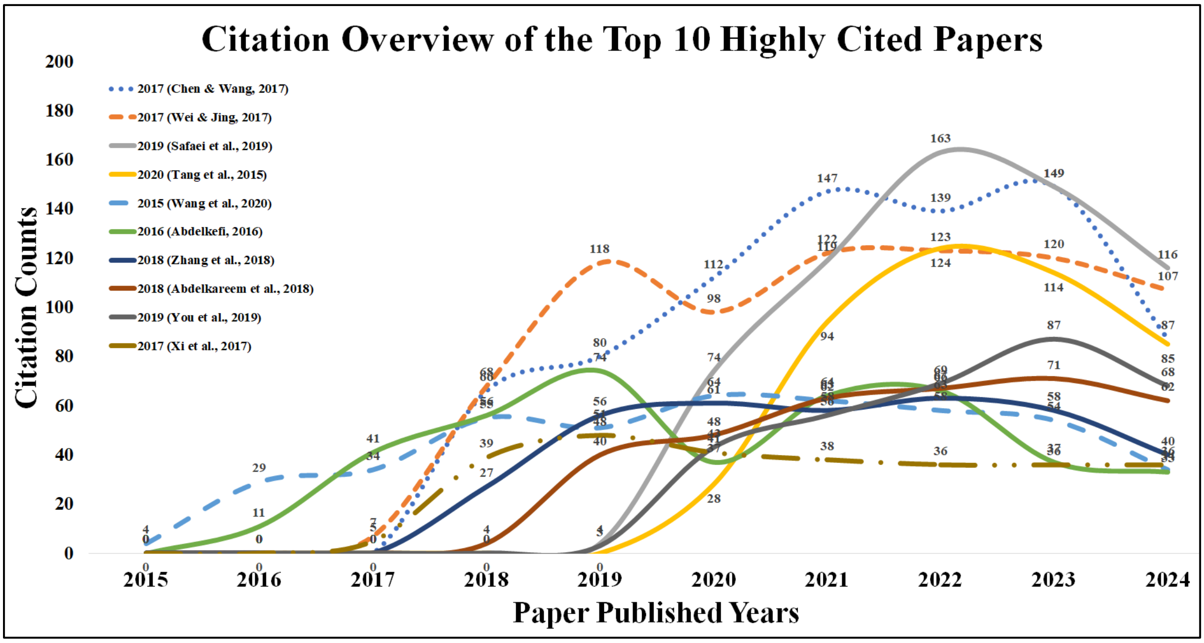

Figure 7: Citation overview of the top 10 highly cited papers

5. Discussion

Vibration Energy and Harvesting demonstrate that global research has shown impressive growth during the last 15 years, from 341 publications in 2015 to 408 in 2024, with the highest number of publications in 2023, with 2528 publications. The maximum number of Total Cited Papers can be found in 2019 (n=363) and the lowest in 2024 (n=148) (Gupta et al., 2023; Kappi et al., 2024). Funding for the papers increased from 108 in the year in 2015 to 283 in the year 2024, but in the years 2022 and 2023, it increased from 305 to 332. The total number of publications cited increased gradually, whereas HCPs increased in 2017 but steadily decreased from 28 to 0 in 2023 and 2024 (Vaishya et al., 2023; Vaishya, Gupta, Kappi, et al., 2024; Vaishya, Gupta, Mamdapur, et al., 2024; Mallikarjuna et al., 2025). It shows that HCPs will decrease in the coming years, but their funding will increase. China emerged as the primary collaborator, contributing 41.66% (n=1850) share of the joint publications in this domain among the top twenty-five countries during 2015-2024, followed by countries like the US and UK published ¼ (n=502) of China's publications and ½ (n=224) of United States publications were published by the United Kingdom, these two countries are having 11.30% (n=502) and 5.04% (n=224) collaboration with other countries respectively. In terms of citation impact, here also all the first three positions went to China, the United States and the United Kingdom by receiving 53.38% (n=32397), 22.26% (n=13513) and 9.38% (n=5658) citations, respectively. Among the top twenty-five countries, the average number of citations for these publications is 3269 (Shaikh & Zeadally, 2016; Al-Quaishi et al., 2024).

6. Research Gaps and Future Directions

Vibration energy harvesting technology is becoming more critical for powering small electronic devices without relying on batteries. Researchers have made significant progress, but several challenges remain, including limited frequency range, low power output, high costs, and design complexity. Based on recent developments, the following key areas need further research:

1. Broadband and low-power harvesting – Most existing harvesters work well only at specific frequencies. A more efficient harvester should operate across a wide range of frequencies. Nonlinear designs, metamaterials, and AI-based optimization can help improve performance.
2. Energy storage and power management – Since the harvested energy is often weak and inconsistent, better storage solutions like super capacitors and efficient power circuits are needed.
3. Durability and reliability – While vibrations are an endless energy source, harvesters wear out over time due to material degradation. Developing flexible, bio-inspired materials and better protective designs can extend their lifespan.
4. Miniaturization and integration – Most current harvesters are too large to work seamlessly with IoT, MEMS, and CMOS technologies. Research is needed on nanoscale designs and self-powered sensors.
5. Hybrid energy harvesting – A single harvester may not always work efficiently. Combining different energy sources (piezoelectric, electromagnetic, and electrostatic methods) or integrating solar and thermal energy can improve reliability.
6. Scalability and mass production – Due to fabrication challenges, many existing designs remain at the research stage. Cost-effective manufacturing techniques are necessary to enable large-scale production and commercialization.

7. Conclusion

Countries such as China, the United States of America and the United Kingdom dominate the Vibration Energy and Harvesting research, showing the gap between high and low-income countries. The quantity of research has shown good progress from 2015 to 2024. Ninety-one articles are highly cited, with more than 100 citations. The HCPs citation range is between 194 and 782; these top twenty HCPs received 7071 citations, with an average of 353.55 citations per publication. In this study, researchers examined the research productivity and innovation trends of Vibration Energy Harvesting from 2015 to 2024 to gain valuable insight into this field's evolution.

8. Author Contributions

Jayaprakash G Hugar: Conceptualization, Data curation
Ghouse Modin Nabeesab Mamdapur: Formal analysis, Software
M. M. Bachalapur: Investigation, Project administration
Pradeep V. Malaji: Supervision, Validation
Ali Kesturu Sabil: Methodology, Validation
Daniil Yurchenko: Investigation, Supervision

9. Source of Funding

None.

10. Conflict of Interest

None.

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