



Review

Sound absorption as a basis for noise reduction studies: Bibliometric analysis

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Abstract: Workplace noise creates negative impacts on human health; therefore, preventive and control actions are compulsory, and sound absorption is one of the ways to prevent and control noise by minimizing noise exposure through the use of sound-absorbing materials. As such, an analysis dealing with the distribution of articles on sound absorption needs to be conducted as a basis for future researchers’ opportunities and interests. This study applied a bibliometric method, involving several stages: A Scopus data search stage using the keyword category “Sound and Absorption” (18,325), followed by a filtering stage for the year range 2015–2024 (8979), article type (5967), English language (5368), keyword “sound absorption” (1730), and journal type (document) (1720). The data analysis stage was conducted using the VOSviewer application (version 1.6.19) and Biblioshiny from Bibliometrix 3 with

RStudio (version 4.3.1) to display bibliometric visualization maps. The results show sound absorption topics spreading in fields as material science (24.8%), physics (22.2%), engineering (22.2%), and environmental science (5.1%). China was the highest contributor, with more than 700 publications. There was an increasing trend in the number of article documents from 2015 (68) to 2024 (332). The journal with the most publications (219) and citations (4,606) was *Applied Acoustics*. The analysis found four clusters: Cluster 1 in red color (47 items), Cluster 2 in green color (46 items), Cluster 3 in blue color (15 items), and Cluster 4 in yellow color (10 items). Based on the analysis results, it can be concluded that sound absorption is still a current study trend that can be the basis for study opportunities in the topic of sound absorption for noise control.

Keywords: noise; sound absorption; noise reduction; bibliometric

1. Introduction

Noise problems frequently occur because of the use of machines to improve goods, services, and productivity for human needs, causing negative impacts on humans, such as psychological disorders [1], cardiovascular disorders [2], and physiological disorders [3,4], among others. Statistics show that long-term exposure to noise is prone to cause physiological and psychological impacts, including increased stress, higher emotional levels, lack of sleep, and disrupted communication [5,6]. According to the Minister of Manpower Regulation No. 5 of 2018, noise is an unwanted sound coming from production machines or work equipment, which at a certain level can cause hearing problems [7]. This forces workplace managers to measure and control the noise in order to achieve exposure levels below the threshold limit value, which aims to prevent the negative impacts of noise.

Receiver control aims to minimize the noise heard by the receivers, while source control focuses on minimizing the amount of noise produced at the source [6,8]. A common method to handle noise is to use sound-absorbing materials or structures to convert sound energy into thermal or strain energy, thus eliminating it [9]. Installing sound-absorbing materials inside buildings is a valuable way to minimize noise. Generally, sound-absorbing materials are divided into resonant absorbers and porous absorbers [9–11].

In the field of environmental engineering and modern acoustic engineering, the development of sound-absorbing materials does not merely focus on acoustic efficiency but also on sustainability and its environmental impact. Recent studies emphasized that natural porous materials such as plant fibers, agricultural waste, and biomass-based materials significantly minimize noise compared to synthetic materials [12]. Furthermore, optimized micro-structure material development, such as gradient porous composites and bio-based resonators, is proven to increase the absorption coefficient by 0.85 at medium frequencies [13]. This highlights the importance of a multidisciplinary approach between material engineering, acoustics, and sustainability in facing the challenges of industrial noise control.

In recent international studies, the focus has not only been on the absorption coefficient but also on the development of sustainable and effective wide frequency ranges. Review studies showed that porous materials are still the primary option as they offer thorough performance in the mid-high frequency range and adaptability through the optimization of their porous structure. Moreover, composites and gradient pore structures (gradient porous composites) have been reported to increase sound absorption by utilizing variations in particle/pore sizes to broaden the absorption band [13]. The parallel composite approach, which combines perforated panel resonators and porous materials, also

shows ultra-broadband performance, making it effective in minimizing noise in the low to medium frequency range [14]. On the other hand, experimental studies highlighted the real potential of biomass-based materials such as agro fibers (kapok, coir, corn husk) and wood residues as environmentally friendly sound absorbers with competitive performance after proper treatment and structural design [15]. These results stress the significance of the integration between structural design (e.g., pore gradient, composite resonator) and the selection of bio-based materials for effective and sustainable industrial noise control solutions.

Studies on sound absorption are in line with the fast-paced advancement of science. Xu et al. [16] found improved sound absorption by size gradient granular materials due to the Brazil-nut effect. Mei et al. [14] studied ultra-broadband sound absorption via a parallel composite structure consisting of perforated panel resonators with tube bundles and porous materials. Pan et al. [17] evaluated the preparation and characterization of carbon nanotubes coated on expanded perlite as sound absorption composite materials. Liu et al. [18] demonstrated the sound absorption characteristics of agro-sourced kapok fibrous materials. Liu et al. [19] studied the sound absorption of porous materials perforated with holes with gradually varying radii. Li et al. [20] examined an acoustic impedance structure consisting of a perforated panel resonator and porous material for low-to-mid frequency sound absorption.

Porous materials are classified into synthetic materials (organic and inorganic) and natural materials. Synthetic fibers are widely used as conventional sound absorption materials, although there are negative impacts on the environment. Studies on sound absorption have advanced toward environmentally friendly products over the last decade, along with the global awareness of eco-friendly materials. Natural materials recently evaluated as study materials include waste palm oil [21], date palm and wheat straw [22], *Eucalyptus globulus* leaves and straw fibers [23], water hyacinth stems [24], *Yucca gloriosa* fibers [25], natural jute [26], pineapple leaf fibers, wood fibers [27] hemp fibers [28], corn husk fibers [29], sugarcane bagasse fibers [30], areca palm sheath fibers [31], and natural kenaf fibers [32].

Recent advances in multifunctional composite materials also emphasize the integration of sound absorption with additional functions such as vibration damping and mechanical energy absorption, which are highly relevant for noise reduction applications in industrial and transportation environments [33]. Furthermore, bioinspired metamaterials with hierarchical architectures have revealed previously unobserved mechanisms for mechanical wave energy absorption, through a combination of local resonance and energy dissipation across structural scales [34].

Based on the preceding discussion, it is necessary to identify and review previous work to analyze and evaluate the development of the sound absorption topic before further studies in related areas. Therefore, numerous review articles need to be explored as outputs, providing a comprehensive overview of sound absorption as an effort to mitigate the negative impacts of excessive noise. As a subsequent step, this study employs bibliometric analysis, a quantitative approach that focuses on the evolution of studies and literature, enabling the identification of trends and the popularity of sound absorption studies. Moreover, this method assists researchers in recognizing collaboration networks and relevant sources. Bibliometric studies are widely applied to assess the influence of publications within a specific domain and to evaluate the impact of particular disciplines or scholars [35]. Therefore, it is necessary to conduct a literature review on sound absorption entitled “Bibliometric Analysis: A Literature Review on Sound Absorption as a Basis for Addressing Noise Issues.”

2. Materials and methods

The bibliometric analysis in this study was conducted by selecting keywords from the Scopus database. The initial keyword search on Scopus used the terms “sound and absorption”, resulting in

18,325 documents. The filtering stage aimed at selecting only works published between 2015 and 2024 (January 1, 2015–December 31, 2024) (8979), of article type (5967), in English (5368), with the keyword “sound absorption” (1730), and of journal type document (1720). The parameters used were noise, sound, and absorption. The flow diagram of the literature screening and selection process is presented in Figure 1.

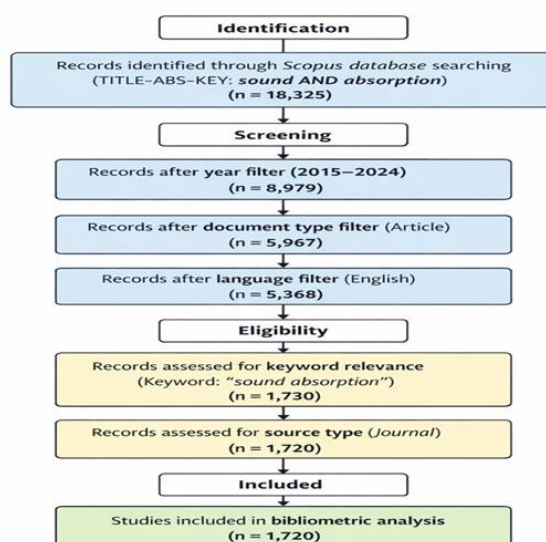


Figure 1. Flow diagram of the literature screening and selection process (Source: Authors’ analysis).

The analysis was the final step in this study, encompassing data processing and analysis using VOSviewer and Biblioshiny, which are applications used to generate bibliometric visualization maps. The analysis was conducted on the numerical data of the selected scientific publications. Some of the analyzed categories included the number of citations received by a publication, the increase or decrease in study trends within a specific field, the extent of collaboration among researchers, and other related indicators.

Data processing of the selected Scopus data was carried out by exporting the files into CSV format, with the options including citation information, bibliographical information, abstract and keywords, funding details, and other information, which were then exported into an Excel document. This method employed several key metrics, including the evolution of publications, journals, contributing institutions, contributing countries, changes in study areas, author analysis, keyword analysis, and the examination of various networks such as co-occurring subjects, journals, citation patterns, collaboration trends, and clusters. To obtain these metrics, several software tools were used. The software employed for this review article included VOSviewer (version 1.6.19) and Biblioshiny from Bibliometrix 3 using RStudio (version 4.3.1) [36].

3. Data collection

3.1. Data information

The analysis of 1720 Scopus documents was conducted using Biblioshiny, resulting in data

information to be further analyzed. Table 1 presents the main information about the data, including document contents, authors, author collaboration, and document types.

Table 1. Scopus data information on sound absorption.

Description	Results
Main information about data	
Timespan	2015–2024
Sources (journals, books, etc.)	407
Documents	1720
Annual growth rate (%)	19.27
Document average age	3
Average citations per document	15.88
References	55,545
Document contents	
Keywords Plus (ID)	8035
Author's keywords (DE)	3760
Authors	
Authors	3870
Authors of single-authored documents	50
Author collaborations	
Single-authored documents	68
Co-authors per document	4.52
International co-authorships (%)	20.06
Document types	
Article	1720

3.2. Analysis of scientific fields on sound absorption

By analyzing 1720 Scopus documents on sound absorption, the percentage of scientific fields studying this topic was identified. Figure 2 reveals that studies on sound absorption are mostly found in the field of materials science (24.8%), followed by physics (22.2%), engineering (22.2%), and environmental science (5.1%). This confirms that the literature on sound absorption from 2015 to 2024 can be utilized as a foundation for developing further studies on sound absorption to address noise-related issues. Such development should take into account perspectives from materials science, physics, environmental science, and engineering. The percentages shown also indicate that these fields provide sufficient opportunities and references for future studies.

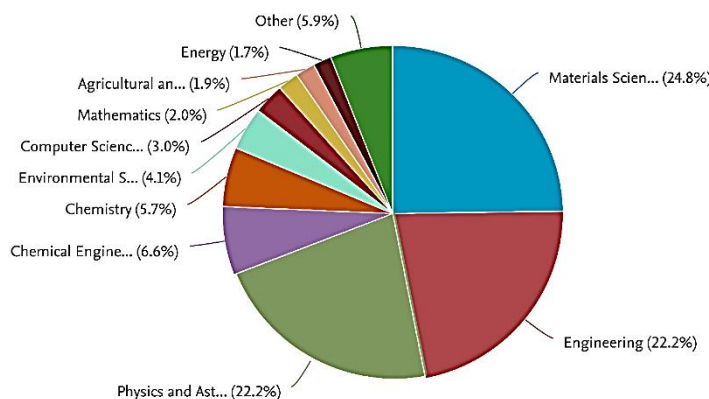


Figure 2. Sound absorption distribution studies across scientific fields (Source: Authors' analysis based on Scopus data, 2025).

3.3. Analysis of country contributions to publications

Through the analysis of 1720 Scopus documents, the ten countries contributing the most publications on sound absorption are China, South Korea, India, Spain, the United States, Iran, France, Turkey, Canada, and Italy. Figure 3 illustrates that among these countries, China is the leading contributor, with more than 700 publications from 2015 to 2024, while Italy has the fewest, with around 50 publications. This result indicates that the topic of sound absorption has attracted global attention and has been studied across various countries. Therefore, in future studies, these ten countries can serve as valuable references for identifying emerging theories, methods, and developments in the field of sound absorption to address noise-related issues.

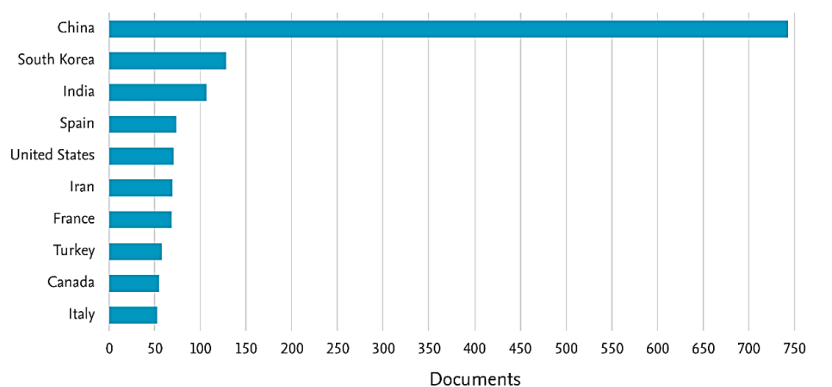


Figure 3. Distribution of countries publishing articles on sound absorption (Source: Authors' analysis based on Scopus data, 2025).

3.4. Analysis of annual publications

The analysis of 1720 Scopus documents on sound absorption provides a comparison of the annual number of articles related to this topic. Figure 4 and Table 2 show that the number of articles published on sound absorption increased from 68 in 2015 to 332 in 2024, indicating a significant growth in publications on this topic over the 2015–2024 period. Although there was a slight decline in 2017 and 2023, the number

of publications rose again this year, indicating a long-term upward trend in the development of studies related to sound absorption. This phenomenon presents a promising opportunity in the coming years to attract greater study interest in discovering new theories, methods, and innovations on sound absorption as an effort to reduce noise, while simultaneously opening prospects for the continuity and sustainability of studies on this topic.

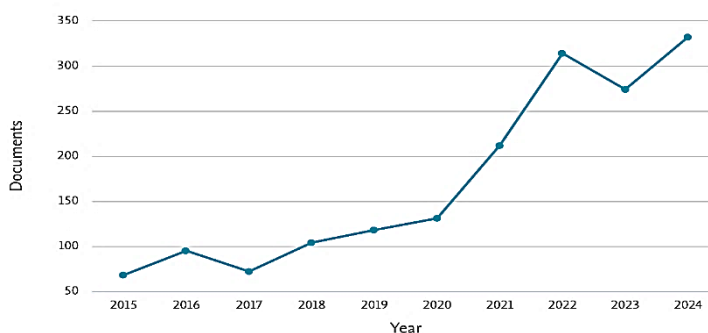


Figure 4. Annual growth in the number of articles related to sound absorption (Source: Authors' analysis based on Scopus data, 2025).

Table 2. Annual publications on sound absorption.

Year	Articles
2015	68
2016	95
2017	72
2018	104
2019	118
2020	131
2021	212
2022	314
2023	274
2024	332

3.5. Journal analysis by number of publications

The analysis of 1720 Scopus-indexed documents using the Biblioshiny application on the topic of sound absorption produced information on the ten journals with the highest number of publications. These include Applied Acoustics (219), Construction and Building Materials (46), Journal of Natural Fibers (46), Materials (46), Journal of Sound and Vibration (43), Journal of the Acoustical Society of America (43), Journal of Building Engineering (28), Polymers (27), Materials and Design (25), and Textile Research Journal (25). Figure 5 shows that the journal that most frequently publishes studies on sound absorption is Applied Acoustics, while the one with the least amount of publications is *Textile Research Journal*. The emergence of journals and their publication numbers reflects the growing attractiveness of this field. Consequently, this provides a strong foundation for the advancement of future studies, as these journals can serve as primary references for new insights and scientific developments related to sound absorption as an improved approach to addressing noise problems.

Among them, *Applied Acoustics* can be considered the primary reference source, as it contains the largest number of publications on the topic of sound absorption.

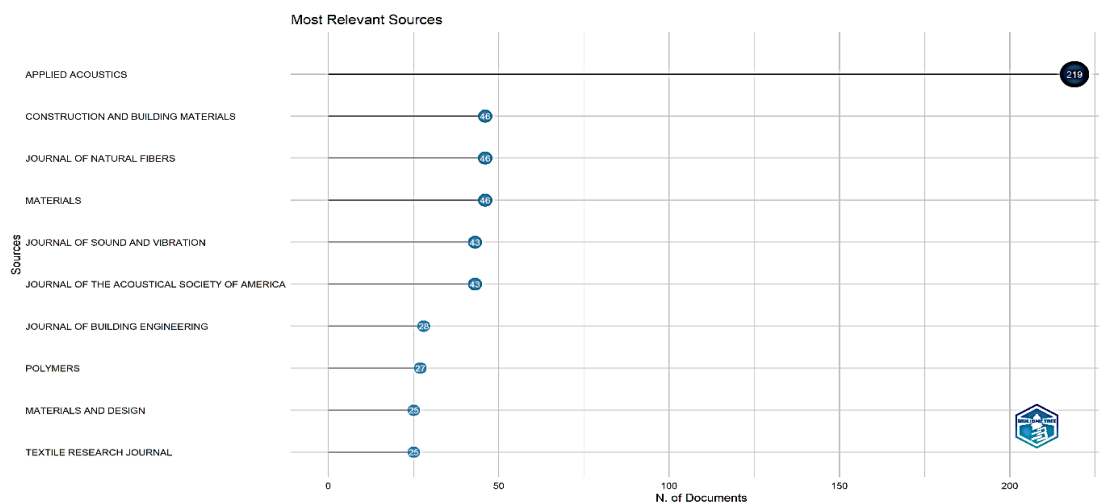


Figure 5. Analysis of journal relevance related to sound absorption (Source: Authors' analysis based on Scopus data, 2025).

3.6. Analysis of article impact on citations

The analysis of 1720 Scopus-indexed documents using the Biblioshiny application on the topic of sound absorption produced information on the ten journals with the highest citation counts for published articles related to sound absorption. Figure 6 illustrates that the journal with the greatest number of citations in this field is *Applied Acoustics*, with a total of 4606 citations. This phenomenon indicates a continuous progression of efforts in the topic of sound absorption, suggesting that this subject remains of high interest to current researchers. It can also be predicted that the trend will persist in future studies, leading to new discoveries and scientific advancements in sound absorption as an increasingly effective approach to addressing noise-related problems.

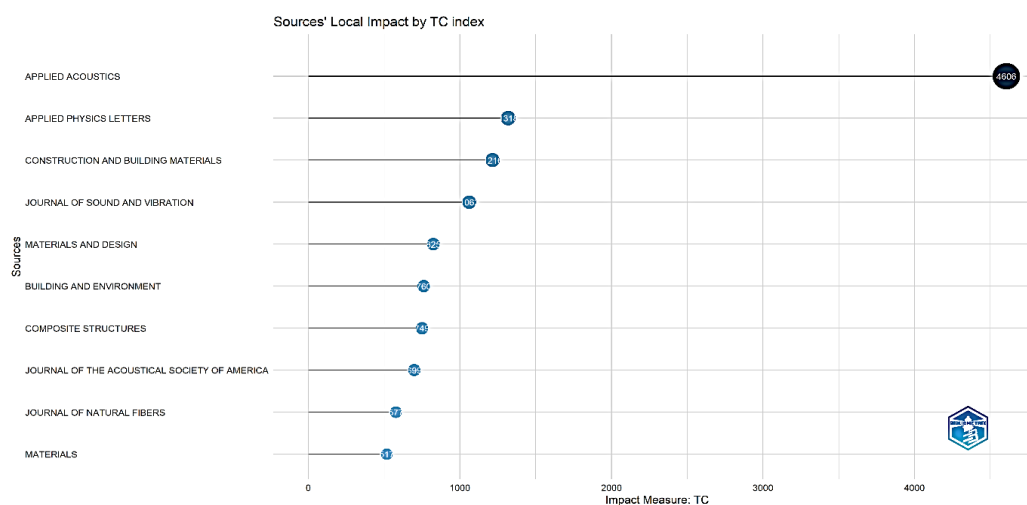


Figure 6. Citation impact of articles and journal occurrence (Source: Authors' analysis based on Scopus data, 2025).

The citation performance of articles in Applied Acoustic journal reflects the strong interest and ongoing development in the field of sound absorption.

3.7. Co-occurrence analysis—All keywords

The co-occurrence analysis (all keywords) illustrates the frequency, co-presence, and proximity of related keywords, consisting of terms that are broadly similar and associated with the same subject area. This approach serves as a content analysis method that generates a visual semantic map, revealing the cognitive structure of the investigated subject through the use of author-defined keywords [37]. Examining the network structure in which keywords appear together is considered one of the most effective methods for identifying scientific trends and themes that have evolved over time, achieved through a concise and summarized visual representation in the form of a map [38].

In this analysis, the VOSviewer application was utilized to process and analyze 1720 Scopus-indexed article documents, with a minimum occurrence threshold of 30 keywords. Figure 7 illustrates that four clusters were identified: Cluster 1 (red), Cluster 2 (green), Cluster 3 (blue), and Cluster 4 (yellow).

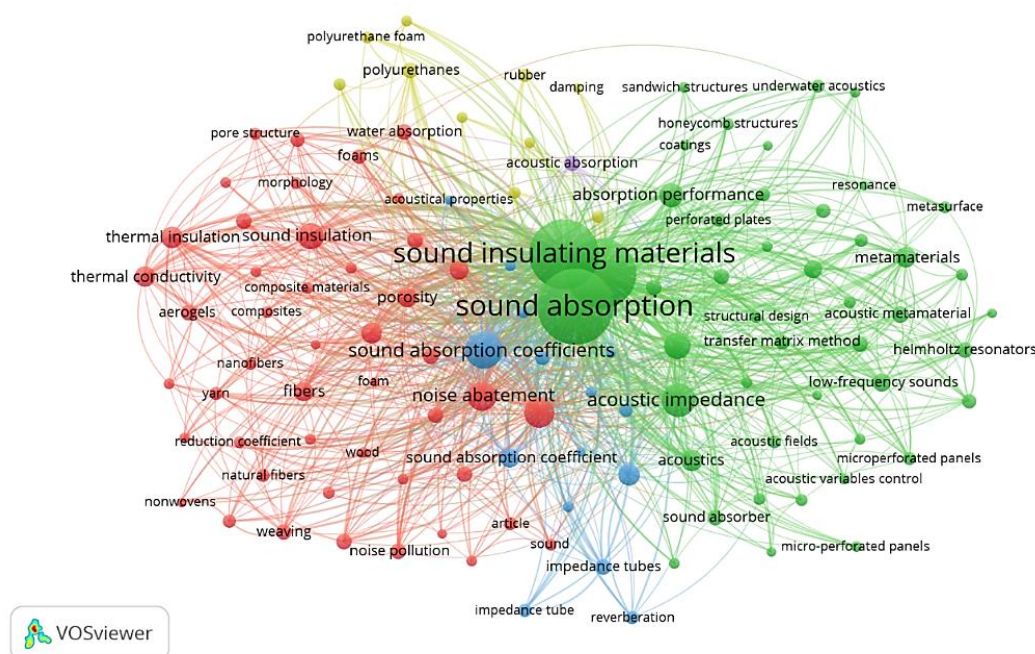


Figure 7. Co-occurrence analysis: All keywords related to the topic of sound absorption (Source: Authors' analysis based on Scopus data, 2025).

Cluster 1, represented in red (47 items), broadly encompasses topics such as sound insulation, acoustic noise, noise abatement, sound absorption properties, thermal insulation, and other related subjects.

Cluster 2, represented in green (46 items), broadly encompasses topics such as sound-insulating materials, sound absorption, acoustic impedance, porous materials, metamaterials, absorption performance, and other related themes.

Cluster 3, represented in blue (15 items), primarily covers topics related to the sound absorption coefficient, architectural acoustics, and impedance tubes.

Cluster 4, represented in yellow (10 items), broadly includes topics such as damping, rubber, and sound absorption characteristics.

4. Discussion

Based on the above analysis, the author concludes that previous studies on sound absorption, as a fundamental aspect of noise control research, should carefully consider the principles of physics. Theories, methods, and equipment derived from physical acoustics play an essential role in understanding and optimizing material behaviour. Studies applying physics-based concepts have shown that acoustic materials with expansion structures exhibit broader and more periodic sound transmission loss (STL) characteristics. Furthermore, when the area expansion ratio ($m = \text{cavity cross-sectional area/inlet or outlet port cross-sectional area}$) increases, the STL curve displays higher peaks or domes. Similarly, a higher perforation area ratio ($r = \text{perforation area/total area}$) and smaller perforation diameter in acoustic materials allow for greater sound absorption across a wide frequency range. Since these three factors (expansion ratio, perforation ratio, and perforation diameter) are interdependent, current material design approaches often adopt an optimization strategy that balances all three parameters [39]. The impedance tube apparatus, as a fundamental instrument in physical acoustics, is used to measure the sound absorption coefficient (SAC). For instance, one study measured the SAC of both control and treated samples using the two-microphone transfer function method with an impedance tube kit (Model: Type 4206, B&K Company, Nærum, Denmark), pulse analysis software, and a spectrum analyser (Model: Type 3560, B&K Company, Nærum, Denmark), in accordance with ISO 10534-2:2001 standards [40].

The literature on sound absorption as a foundation for noise control studies should also take into account the field of materials science. This discipline provides essential theoretical and practical knowledge for selecting appropriate materials to be used as sound absorbers in noise prevention and control efforts. For instance, studies have shown that in porous absorbers made of fibrous materials, sound waves typically propagate through interconnected pore networks. Due to the extremely small pore size and the interaction between sound waves and the pore walls, viscous and thermal dissipation occur, converting the sound wave energy into heat [41]. Moreover, the field of engineering must also be considered in sound absorption studies, as it plays a critical role in determining factors that influence noise reduction performance. These include thickness (sound absorption increases with greater material thickness), density (higher density increases energy loss due to more complex sound pathways or tortuosity within the absorber), and tensile strength (which reflects the mechanical suitability of fibers). Studies indicate that sustainable construction materials such as sugarcane bagasse waste demonstrate competitive thermal and acoustic performance, making them viable alternatives for environmentally friendly sound absorption applications [25,30,32,42].

Contemporary empirical insights illustrate that human auditory perception tends toward a frequency spectrum of 50–6000 Hz. This distinguishable spectrum is further divided into three distinct sub-ranges: A low-frequency resonance encompassing and falling below 300 Hz, a mid-frequency domain spanning 300–2000 Hz, and a high-frequency range extending beyond 2000 Hz. It is the mid-frequency domain that encapsulates the full range of sounds that make up the everyday human auditory experience. This includes speech, animal vocalizations, and musical sonorities [21].

The sound absorption process can be understood as a longitudinal pressure wave that moves along the particles in the medium. Friction phenomena occur between air particles and materials, which causes sound energy to dissipate into heat. Sound absorption coefficient tests are carried out at different frequencies, usually at 250, 500, 1000, and 2000 Hz [43]. Acoustic waves must pass through a more torturous path; therefore, acoustic energy is dissipated into heat during its propagation due to the viscous friction of air particles, and thus SAC increases [29].

The literature on sound absorption as a foundation for noise control studies should also

incorporate insights from environmental science, particularly regarding the use of natural fibers as sound-absorbing materials. These natural materials are porous, allowing sound energy to dissipate within their pores. They are lightweight and offer additional advantages such as environmental friendliness and non-toxicity [44]. Natural fibers derived from agricultural waste (rice straw, wheat straw, husks, vegetable residues, banana stems, jute fibers, peanut shells, sawmill residues, coconut coir, and cotton stalk) can serve as sustainable alternatives to synthetic fibers for acoustic absorption materials. These fibers are easily available and biodegradable, making them ideal for long-term noise reduction practices [29,45]. Eco-friendly materials (natural fibers) are produced and utilized to minimize environmental degradation because they are biodegradable, renewable, and sustainable. Moreover, these materials contribute to waste reduction and decrease dependency on non-renewable raw resources. The integration of environmentally friendly materials represents a crucial step toward achieving a more sustainable future [46].

Natural fibers (cellulose, hemicellulose, lignocellulose) are fibers produced through earth processes or from the bodies of plants or animals. Natural fibers are abundant and relatively easy to obtain. Natural fiber-reinforced composites have a significant impact on the acoustic field. The superior acoustic qualities of natural fibers are a result of their capacity to absorb sound. The use of organic fiber composites in building soundproofing is becoming increasingly important in the modern world. Modifying the composition, porosity, thickness, and other characteristics of natural fibers can change how well they absorb sound. Most natural fibers behave like porous absorbers in terms of sound absorption. The best durability for acoustic applications is provided by the way these natural fibers are bound with a binder. Composites made from natural fibers are inexpensive and biodegradable [47].

The author also observes that the results of the bibliometric analysis of thousands of international publications on sound absorption published during the 2015–2024 period indicate a significant increase in global study interest and direction. Based on the results of this study, the field of sound absorption is predominantly represented by studies in materials science (24.8%), physics (22.2%), and engineering (22.2%), reflecting its multidisciplinary nature and the synergy across scientific domains [48]. The author believes that this trend signifies a paradigm shift, from merely achieving acoustic efficiency toward the innovation of sustainable and environmentally friendly materials.

The noise reduction coefficient (NRC) is determined by taking the arithmetic mean of the sound absorption coefficients (α) at frequencies of 250, 500, 1000, and 2000 Hz (ASTM C423 2017):

$$NRC = \frac{\alpha_{250} + \alpha_{500} + \alpha_{1000} + \alpha_{2000}}{4} \quad (1)$$

The NRC value indicates a material's ability to absorb sound. Like α , an NRC value of 0 indicates perfect sound reflection, while an NRC value of 1 indicates perfect sound absorption.

The average sound absorption (SAA), as defined by ASTM C423-09a, is calculated as the arithmetic mean of 12 1/3-octave band sound absorption coefficients (α) in the frequency range 200–2500 Hz (as shown in Eq (1)). This indicates a material's ability to absorb sound across a broader frequency spectrum. Similar to the NRC, an SAA value of 0 indicates perfect sound reflection, while an SAA value of 1 indicates perfect sound absorption.

$$SAA = \frac{\alpha_{200} + \alpha_{250} + \alpha_{315} + \alpha_{400} + \alpha_{500} + \alpha_{630} + \alpha_{800} + \alpha_{1000} + \alpha_{1250} + \alpha_{1600} + \alpha_{2000} + \alpha_{2500}}{12} \quad (2)$$

Each α represents the sound absorption coefficient at its respective frequency. For example, α_{200} indicates the coefficient at 200 Hz, α_{250} at 250 Hz, and so on [49].

The analysis also indicates that China ranks as the leading country in scientific publications related to sound absorption, followed by the United States and Japan, while *Applied Acoustics* stands out as the most productive and influential journal in this field [16,48]. Accordingly, the author suggests that future study directions in this domain should focus on strengthening international collaborations, increasing the utilization of natural materials, and employing bibliometric approaches to identify emerging trends, key keywords, and underexplored gaps.

Furthermore, the author emphasizes that the bibliometric approach not only provides statistical insights but also serves as a strategic tool for formulating a study roadmap in noise control studies based on sound absorption. The results of this study may serve as both academic and practical foundations for guiding future innovations in sustainable sound-absorbing materials through the integration of acoustic physics, material engineering, and environmental science. Thus, sound absorption studies should not be viewed solely from a technological standpoint but also as a contribution to achieving the Sustainable Development Goals (SDGs), particularly in the areas of industry, innovation, and environmental sustainability [12,50].

5. Conclusions

Based on the above analysis, it can be concluded that the topic of sound absorption remains a current study trend, with a consistently upward trajectory in publication growth. Studies on sound absorption as a key approach in noise control have revealed patterns in publications, journals, citations, article clusters, and country contributions, each providing a strong foundation for future study opportunities and scholarly interest in this field. Furthermore, it is essential to consider the multidisciplinary aspects of this topic, particularly the contributions from materials science (24.8%), physics (22.2%), engineering (22.2%), and environmental science (5.1%).

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools writing this article.

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Conflict of interest

All authors declare no conflict of interest in this paper.

References

1. Zhang N, Liu C, Zhang M, et al. (2025) Effects of traffic noise on the psychophysiological responses of college students: An EEG study. *Build Environ* 267: 112171. <https://doi.org/10.1016/j.buildenv.2024.112171>
2. Hoffmann B, Vienneau D (2024) At the heart of the matter: do we still underestimate noise effects on cardiovascular health? *Lancet Reg Health-Eu* 47: 101134. <https://doi.org/10.1016/j.lanepe.2024.101134>
3. Mir M, Nasirzadeh F, Bereznicki H, et al. (2023) Construction noise effects on human health: Evidence from physiological measures. *Sustain Cities Soc* 91: 104470. <https://doi.org/10.1016/j.scs.2023.104470>
4. Xing X, Li H, Zhong B, et al. (2021) Assessment of noise annoyance level of shield tunneling machine drivers under noisy environments based on combined physiological activities. *Appl Acoust* 179: 108045. <https://doi.org/10.1016/j.apacoust.2021.108045>
5. Sheng DCV, Yahya MNB, Din NBC, et al. (2024) Potential of wood fiber/polylactic acid composite microperforated panel for sound absorption application in indoor environment. *Constr Build Mater* 444: 137750. <https://doi.org/10.1016/j.conbuildmat.2024.137750>
6. Khan J, Burdzik R (2023) Measurement and analysis of transport noise and vibration: A review of techniques, case studies, and future directions. *Measurement* 220: 113354. <https://doi.org/10.1016/j.measurement.2023.113354>
7. Pemerintah Indonesia. *Peraturan Menteri Ketenagakerjaan Republik Indonesia Nomor 5 Tahun 2018 tentang Keselamatan dan Kesehatan Kerja Lingkungan Kerja*, Jakarta: Kementerian Ketenagakerjaan RI, 2018.
8. Murphy E, Douglas O (2018) Population exposure to road traffic noise: Experimental results from varying exposure estimation approaches. *Transp Res D-Tr E* 58: 70–79. <https://doi.org/10.1016/j.trd.2017.11.006>
9. Cao D, Wang L, Wang J, et al. (2025) Design and sound absorption analysis of labyrinthine acoustic metamaterials based on fractal theory. *Int J Solids Struct* 306: 113121. <https://doi.org/10.1016/j.ijsolstr.2024.113121>
10. Zhang X, Qu Z, Wang H (2020) Engineering acoustic metamaterials for sound absorption: From uniform to gradient structures. *iScience* 23: 101110. <https://doi.org/10.1016/j.isci.2020.101110>
11. Mamtaz MH, Fouladi M, Al-Atabi M, et al. (2016) Acoustic absorption of natural fiber composites. *J Eng* 2016: 1–11. <https://doi.org/10.1155/2016/5836107>
12. Yang W, Zhang S, Li H (2023) Bio-based acoustic materials: a sustainable approach to noise control. *Renew Mater Sci* 2: 142–157. <https://doi.org/10.1016/j.rematsci.2023.142157>
13. Zhang T, Chen Y, Hu X (2024) Gradient porous composites for enhanced sound absorption. *Compos Struct* 340: 117328. <https://doi.org/10.1016/j.compstruct.2023.117328>
14. Mei Z, Yang H, Ding Y, et al. (2023) Ultra-broadband sound absorption via a parallel composite structure consisting of perforated panel resonators with tube bundles and porous material. *Appl Acoust* 222: 110071. <https://doi.org/10.1016/j.apacoust.2024.110071>
15. Kassim DH, Ramlan R, Putra A (2023) Enhancement of sound absorption of coir fiber using thin layer of kapok fibers. *J Nat Fibers* 20. <https://doi.org/10.1080/15440478.2022.2164103>
16. Xu L, Wang M, Li H, et al. (2025) Improved sound absorption by size gradient granular materials due to Brazil-nut effect. *Appl Phys Lett* 124: 091903. <https://doi.org/10.1016/j.apacoust.2024.110416>

17. Pan J, Hu J, Hu C, et al. (2023) Preparation and characterization of carbon nanotubes coated on expanded perlite as sound absorption composite materials. *Mater Sci Eng B* 296: 116697. <https://doi.org/10.1016/j.mseb.2023.116697>
18. Liu X, Xu J, Zhu Y, et al. (2022) Sound absorption characteristics of agro-sourced kapok fibrous materials. *Ind Crops Prod* 188: 115661. <https://doi.org/10.1016/j.indcrop.2022.115661>
19. Liu X, Ma X, Yu C, et al. (2022) Sound absorption of porous materials perforated with holes having gradually varying radii. *Aerosp Sci Technol* 120: 107229. <https://doi.org/10.1016/j.ast.2021.107229>
20. Li B, Liu B, Chang D (2021) An acoustic impedance structure consisting of perforated panel resonator and porous material for low-to-mid frequency sound absorption. *Appl Acoust* 180: 108069. <https://doi.org/10.1016/j.apacoust.2021.108069>
21. Martwong E, Yingshataporn-a-nan T, Minanandana T, et al. Sound absorption and thermal insulation materials from waste palm oil for housing application: Green polyurethane/water hyacinth fiber sheet composite. *Constr Build Mater* 438: 137007. <https://doi.org/10.1016/j.conbuildmat.2024.137007>
22. Ali A, Alabdulkarem A, Nuhait A, et al. (2022) Characteristics of agro waste fibers as new thermal insulation and sound absorbing materials: Hybrid of date palm tree leaves and wheat straw fibers. *J Nat Fibers* 19: 6576–6594. <https://doi.org/10.1080/15440478.2021.1929647>
23. Ali M, Alabdulkarem A, Nuhait A, et al. (2020) Thermal and acoustic characteristics of novel thermal insulating materials made of Eucalyptus globulus leaves and wheat straw fibers. *J Build Eng* 32: 101452. <https://doi.org/10.1016/j.jobe.2020.101452>
24. Marín MO, Román S, Escobar VG, et al. (2023) Thermal performance and sound absorption capability of water hyacinth stems-based materials. *J Clean Prod* 425: 138903. <https://doi.org/10.1016/j.jclepro.2023.138903>
25. Soltani P, Taban E, Faridan M, et al. (2020) Experimental and computational investigation of sound absorption performance of sustainable porous material: Yucca gloriosa fiber. *Appl Acoust* 157: 106999. <https://doi.org/10.1016/j.apacoust.2019.106999>
26. Bansod PV, Mohanty AR (2016) Inverse acoustical characterization of natural jute sound absorbing material by the particle swarm optimization method. *Appl Acoust* 112: 41–52. <https://doi.org/10.1016/j.apacoust.2016.05.011>
27. Putra A, Or KH, Selamat MZ, et al. (2018) Sound absorption of extracted pineapple-leaf fibres. *Appl Acoust* 136: 9–15. <https://doi.org/10.1016/j.apacoust.2018.01.029>
28. Pan Y, Qian Y, Gao Y, et al. (2024) Waste ramie fiber/EVA composites with wideband sound-absorbing performance with mixing and foaming process. *Ind Crops Prod* 221: 119325. <https://doi.org/10.1016/j.indcrop.2024.119325>
29. Fattahi M, Taban E, Soltani P, et al. (2023) Waste corn husk fibers for sound absorption and thermal insulation applications: A step towards sustainable buildings. *J Build Eng* 77: 107468. <https://doi.org/10.1016/j.jobe.2023.107468>
30. Mehrzad S, Taban E, Soltani P, et al. (2022) Sugarcane bagasse waste fibers as novel thermal insulation and sound-absorbing materials for application in sustainable buildings. *Build Environ* 211: 108753. <https://doi.org/10.1016/j.buildenv.2022.108753>
31. Raj M, Fatima S, Tandon N (2020) A study of areca nut leaf sheath fibers as a green sound-absorbing material. *Appl Acoust* 169: 107490. <https://doi.org/10.1016/j.apacoust.2020.107490>
32. Lim ZY, Putra A, Nor MJM, et al. (2018) Sound absorption performance of natural kenaf fibres. *Appl Acoust* 130: 107–114. <https://doi.org/10.1016/j.apacoust.2017.09.012>

33. Wang Q, Zhou L, Xu M (2025) Recent advances in multifunctional composite materials. *Prog Mater Sci* 139: 101120.
34. Chen R, Huang T, Fang D (2024) Unprecedented mechanical wave energy absorption in bio-inspired multifunctional architected metamaterials. *Adv Mater* 36: 2309876
35. Marathe Ł, Sadowski Ł, Shree N (2024) Geopolymer and alkali-activated permeable concrete pavements: Bibliometrics and systematic current state-of-the-art review, applications, and perspectives. *Constr Build Mater* 421: 135586. <https://doi.org/10.1016/j.conbuildmat.2024.135586>
36. Cárdenas AMA, Lacasta M, Haurie L (2024) Bibliometric analysis of research on thermal, acoustic, and/or fire behaviour characteristics in bio-based building materials. *Constr Build Mater* 432: 136569. <https://doi.org/10.1016/j.conbuildmat.2024.136569>
37. Nabgan W, Ikram M, Alhassan M, et al. (2023) Bibliometric analysis and an overview of the application of the non-precious materials for pyrolysis reaction of plastic waste. *Arab J Chem* 16: 104717. <https://doi.org/10.1016/j.arabjc.2023.104717>
38. Ortiz FC, Arcos PP, Feijooet RJH, et al. (2024) Waste-to-energy technologies for municipal solid waste management: Bibliometric review, life cycle assessment, and energy potential case study. *J Clean Prod* 480: 143993. <https://doi.org/10.1016/j.jclepro.2024.143993>
39. Sahu R, Mandal BB (2024) Development of tunable acoustic materials with inline cavity structure for enhanced sound absorption and transmission loss. *J Build Eng* 82: 108305. <https://doi.org/10.1016/j.jobe.2023.108305>
40. Kolya H, Kang CW (2024) Herbal waste as a renewable resource for sound absorption: An eco-conscious approach for wall panel. *J Build Eng* 82: 108249. <https://doi.org/10.1016/j.jobe.2023.108249>
41. Taban A, Khavanin A, Jafari AJ, et al. (2019) Experimental and mathematical survey of sound absorption performance of date palm fibers. *Heliyon* 5: e01977. <https://doi.org/10.1016/j.heliyon.2019.e01977>
42. Suhaeri S, Fulazzaky MA, Husaini H, et al. (2024) Application of Scirpus grossus fiber as a sound absorber. *Heliyon* 10: e28961. <https://doi.org/10.1016/j.heliyon.2024.e28961>
43. Meena K, Singh M, Soni K (2023) Sound absorption behaviour of vetiver grass fibre-based manufactured pine board. *Mapan* 38: 55–62. <https://doi.org/10.1007/s12647-022-00550-9>
44. Raj M, Fatima S, Tandon N (2020) Recycled materials as a potential replacement to synthetic sound absorbers: A study on denim shoddy and waste jute fibers. *Appl Acoust* 159: 107070. <https://doi.org/10.1016/j.apacoust.2019.107070>
45. Sharma S, Sudhakara P, Singh J, et al. (2023) Emerging progressive developments in the fibrous composites for acoustic applications. *J Manuf Process* 102: 443–477. <https://doi.org/10.1016/j.jmapro.2023.07.053>
46. Martínez I, Mendizabal V, Roncero MB, et al. (2024) Towards sustainable building solutions: Development of hemp shiv-based green insulation material. *Constr Build Mater* 414: 134987. <https://doi.org/10.1016/j.conbuildmat.2024.134987>
47. Jadhav S, Kulkarni M (2024) Acoustics characterization of reinforced composite for noise reduction. *Mater Today Proc*. <https://doi.org/10.1016/j.matpr.2024.05.006>
48. Mei H, Yang H, Ding Y, et al. (2024) Ultra-broadband sound absorption via a parallel composite structure consisting of perforated panel resonators with tube bundles and porous material. *Appl Acoust* 222: 110071. <https://doi.org/10.1016/j.apacoust.2024.110071>
49. Kolya H, Kang CW (2024) Unveiling enhanced sound absorption in coconut wood through hemicellulose and lignin modification. *Int J Biol Macromol* 276: 134083. <https://doi.org/10.1016/j.ijbiomac.2024.134083>

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50. Zhang J, Zhang J, Hou H, et al. (2024) Prediction of sound absorption coefficient of film multi-cavity materials based on generalized regression neural network (GRNN). *Appl Acoust* 224: 110134. <https://doi.org/10.1016/j.apacoust.2024.110134>



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