

# Sugarcane Wasted Fibre as a Sustainable Sound Absorber at Different Thickness

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## Abstract

Traditional sound absorption panels composed of synthetic materials are advantageous due to their efficacy in reducing noise levels. The utilisation of synthetic materials poses considerable health hazards and environmental issues that require urgent consideration. To reduce the adverse effects of synthetic materials, a feasible option is the utilisation of natural fibres, such as sugarcane bagasse. This study utilised sugarcane bagasse, along with gypsum powder and a bio-adhesive serving as a binder, to create panels of two distinct thicknesses (50 mm and 30 mm). The sound absorption performance was evaluated using an impedance tube test in accordance with BS EN ISO-10534-2:2001-transfer function method, spanning low to high frequencies. Moreover, the noise reduction coefficient is calculated using the formula to assess the sample's sound absorption capability. Results indicate that the sugarcane bagasse panel demonstrates favourable outcomes, particularly at lower frequencies for thicker specimens. The 50-mm-thick sample demonstrates peak sound absorption coefficients (SAC) of 0.82 at 400 Hz, but the 30-mm-thick sample attained a value of 0.69 at 800 Hz. Analysis of linear regression indicates that sound absorption performance enhances with increased sample thickness, as the 50 mm samples exhibit higher noise reduction coefficients (NRC) of 0.39, compared to the 0.36 coefficients of the 30 mm samples. The porous structure of sugarcane fibres enables the trapping of sound waves, hence facilitating noise reduction. Switching from synthetic to natural fiber-based sound-absorbing panels, particularly those made from sugarcane bagasse, provides a feasible and sustainable approach to noise reduction across different sectors.

## 1. Introduction

Sound absorption is a crucial concept in the realm of acoustics, as it pertains to the ability of a material to reduce the reflection of sound waves. When sound waves encounter a surface, they can either be absorbed, reflected, or transmitted. Absorption occurs when the sound wave energy is converted into heat within the material, thus reducing its amplitude and preventing it from being reflected into the environment [1]. Most sound absorption panels are made from synthetic materials such as fiberglass, mineral wool, and polyurethane foam. These are norm in many industries due to their effectiveness at reducing noise levels [1]. However, the use of these materials poses significant health risks and environmental challenges that cannot be ignored. One major concern with synthetic sound absorbers is the release of harmful chemicals and microfibers into the environment [2].

Natural fibers are becoming increasingly popular as a sustainable and effective solution for sound absorption. Their inherent properties make them attractive alternatives to conventional materials like fiberglass. Unlike synthetic materials, natural fibers are renewable resources that can be grown and harvested, minimizing environmental impact [3]. Sugarcane bagasse, the fibrous leftover that remains after sugar is extracted, is one of the byproducts of the sugar manufacturing process. Unfortunately, this material is often considered a waste product and disposing of it poses environmental challenges. However, by reusing sugarcane bagasse to create sound absorption samples, waste management issues and reduce pollution can be reduced. This initiative aligns with sustainable development goals by promoting the use of renewable and biodegradable materials in place of synthetic, non-renewable alternatives that have negative environmental and health impacts [4].

This study aims to assess how well sugarcane wasted fiber can absorb sound. This includes the determination of sound absorption coefficient at various thicknesses and its noise reduction coefficients. The processed sugarcane bagasse will be mixed using gypsum powder and natural adhesive to form an acoustic sample. Gypsum has been chosen as a binder due to its cross link of hydration, dense morphology, and its ability to raise the sample's compressive and flexural strengths [5]. The thicknesses of the sample are set at 30 mm, and 50 mm has been verified using a variety of experimental techniques, including impedance tube tests, guaranteeing that the theoretical models and actual outcomes match [6]. Sound absorption coefficients of samples were determined according to BS EN ISO 10534-2:2001 between frequencies ranging from 160 Hz to 6300 Hz.

## 2. Performance of Sugarcane Bagasse as Sustainable Acoustic Absorber

Sugarcane bagasse is the fibrous residue remaining after juice extraction from sugarcane. The appearance of sugarcane bagasse is characterized by its fibrous structure and complex morphology. When visually examined, sugarcane bagasse typically consists of fiber structures and pith. The fiber surface displays parallel stripes partially covered with residual material, while the pith is a more fragile and fragmented structure containing small pores connecting neighboring cells on the surface of the walls [7].

In past studies, sugarcane bagasse has shown promising potential as an effective sound-absorbing material as studied by Mehrzad et. al. [8], Hassan et. al., [9], Rozli & Azmir [10] and Malawade & Jadhav [11]. Based on Mehrzad et. al. [8], the results of sound absorption demonstrated that the sugarcane bagasse fibers' strong performance in the low- and mid-frequency bands. Because of their porous nature, composites made of natural fibers may absorb sound very effectively [9]. In addition, the sample's capacity to absorb sound is also influenced by factors like panel thickness.

Research by Rozli & Azmir [10] shows that thicker panels are more effective at absorbing lower frequencies, while thinner panels are better suited for higher frequencies. Thicker acoustic materials tend to have higher absorption coefficients, resulting in improved performance in terms of both amplitude and frequency bandwidth [11]. This suggests that increasing the thickness of acoustic samples can enhance their sound absorption capabilities as been proven by Taaban [12]. Material thickness is not the only factor that affects sound absorption. Acoustic performance is probably influenced by a number of important factors, including internal structure, material composition, airflow resistivity and density. Significantly, the moderately thick material (0.79–1.30 mm) continued to perform reasonably well (SAC = 0.60), presumably as a result of its high airflow resistivity ( $6250 \text{ N}\cdot\text{s}/\text{m}^4$ ), which can improve the dissipation of sound energy [13]. Furthermore, the composition and structure of the fiber used in acoustic materials can also impact their ability to absorb sound at different frequencies [14]. Therefore, a key component of the effectiveness of sound absorbing materials, such as those derived from sugarcane bagasse, is their thickness. Better absorption is achieved by thicker materials, particularly for low-frequency sounds, since sound waves must travel a greater distance through them.

**Table 1** Summary on sound absorption of sugarcane bagasse

Sample Density	Sound Absorption Performance	Significant Findings	Reference
100 to 200 kg/m <sup>3</sup>	The generated samples' noise reduction coefficient (NRC) and sound absorption average (SAA) ranged from 0.27 to 0.62 and 0.26-0.64, respectively. The outcomes demonstrated the sugarcane bagasse fibers' strong performance in the low- and mid-frequency bands.	Tortuosity and flow resistance increases as bulk density increases. Flow resistance increases when air flows through increasingly tortuous channels as bulk density (fiber volume percentage) increases.	[8]

Sample Density	Sound Absorption Performance	Significant Findings	Reference
100 to 200 kg/m <sup>3</sup>	Acoustical properties at of sugarcane fiber-based composites 4000Hz 0.63 coefficients.	Their porous nature, composites made of natural fibers may absorb sound very effectively. Sound absorption performance can be improved by alkali- treated surfaces.	[9]
244 kg/m <sup>3</sup> , 407 kg/m <sup>3</sup> , 487 kg/m <sup>3</sup> , 569 kg/m <sup>3</sup> , 812 kg/m <sup>3</sup> , & 1136 kg/m <sup>3</sup>	Thicker sample of sugarcane bagasse peaked at higher value (0.81) in middle range frequency and thinner sample peaked (0.76) at high range frequency. The performance at middle range frequency can be improved by increasing the thickness of sample, even if the fiber mass used is not increased.	It has been shown that adding an air gap and thickening the sample may both increase the sound absorption coefficient. Sound absorption efficiency is further enhanced by optimal density. The largest sound transmission loss and noise reduction coefficient are found in the thickest sample.	[10]
200 kg/m <sup>3</sup>	A sample with a thickness of 10 mm has been chosen and examined for each of the frequency ranges. For frequencies up to 4500 Hz, it is discovered that the sound absorption coefficient rises with increasing sound frequency. For the frequency of 4500 Hz, the maximum acoustic absorption coefficient is 0.60 coefficients.	The fibrous material's thickness significantly affects the acoustic performance. As the material gets thicker, so do the flow resistance and the acoustic absorption coefficient.	[11]
n.d.	Thickness between 0.29-0.37 mm SAC: 0.65  Thickness between 0.79-1.30 mm Airflow resistivity (N.s.m <sup>-4</sup> ): 6250 SAC: 0.60  Thickness between 2.32-3.34 mm SAC: 0.575  Thickness between 5.31-7.20 mm SAC: 0.26	The findings indicate that thinner materials exhibit higher sound absorption coefficients compared to their thicker counterparts. The samples within the 0.29–0.37 mm range achieved the highest SAC value of 0.65, suggesting superior acoustic performance. As thickness increased, SAC values showed a gradual decline, with the thickest group (5.31–7.20 mm) demonstrating the lowest SAC at 0.26.	[13]

Based on previous studies, it was concluded that sugarcane bagasse has become a promising option for environmentally friendly sound-absorbing applications due to its unique fibrous structure and porous morphology. Because of its inherent porosity and fibrous composition, numerous studies have consistently shown that it can absorb sound, especially in the low- and mid-frequency ranges. While material thickness is important, with thicker panels typically providing better absorption at lower frequencies, other physical characteristics such as density, airflow resistivity, internal structure, and fibre arrangement also have an impact on overall acoustic performance. Furthermore, these reviews highlight sugarcane bagasse's potential as an affordable, renewable substitute for acoustic material development. Its effectiveness in a variety of building and environmental acoustic contexts can be greatly increased by optimising its physical properties, such as thickness and composition.

## 2.1 Thickness Effects on Sound Absorption Performance

The thickness of sound-absorbing materials influences the ability of the materials to absorb sound. Thicker materials tend to have better sound absorption, especially at lower frequencies. This is due to the sound waves having a longer distance to travel within the materials. For instance, fibrous materials like sugarcane bagasse show a noticeable increase in sound absorption as their thickness increased [12]. This concept applies to many acoustic materials, including sugarcane bagasse.

Study by Ewe et. al [14] on the use of oil palm natural fibers as sound absorbing materials reveals thickness of materials significantly effects the sound absorber. Increasing thickness improves sound absorption, especially

at lower frequencies. The results show that all thickness shows an excellent Sound Absorption Coefficient (SAC) of 0.8 except for the 10 mm thickness sample. Similarly, findings by Samaei et. al. [15] demonstrated that raising the fibro granular composite's thickness from 20 to 50 mm raises the SAC values. This was due to the acoustic waves' travel duration and distance both rose with an increase in the medium's thickness. Study by Taban [12] comparing sound absorption of kenaf and date palm fibers at different thicknesses between 25 mm to 55 mm. This study also proves that the thickness and bulk density of samples plays an important role causing the increases of SAC values especially at lower frequencies.

Finally, a study by Rozli and Azmir [10] demonstrates thicker fiber panels substantially improve their ability to absorb sound, particularly at low frequencies below 1000 Hz. This also due to thicker sample provide a longer path for sound waves to dissipate through friction and thermal exchange. The most effective panels were those with thicknesses between 20 and 40 mm; after 40 mm, diminishing returns were noted. A thickness of 30–40 mm was ideal for broadband absorption, especially in the speech-relevant range of 500–2000 Hz, although thinner panels (10–20 mm) functioned well at higher frequencies above 2000 Hz. Furthermore, because of its higher porosity and stiffness, coir fibre performed better than oil palm fibre of the same thickness.

The collective findings of several studies demonstrate that thickness plays a crucial role in improving the natural fiber-based materials' ability to absorb sound, especially at low frequencies. Because thicker materials give sound waves a longer path, more energy can be released through friction and thermal exchange inside the fibre structure. For example, fibro granular composites, sugarcane bagasse, oil palm fibres, kenaf, date palm, and coir fibres all showed enhanced Sound Absorption Coefficients (SAC) with thickness. Most of the research found that a thickness range of 20 to 40 mm was ideal, after which diminishing returns were noted. Notably, because of its greater porosity and stiffness, coir fibre performed better than oil palm fibre at the same thickness. These results highlight how crucial it is to maximise thickness when designing sustainable acoustic materials to achieve efficient broadband sound absorption.

### 3. Methodology

The methodology of this research involved a structured approach to ensure a thorough investigation into the acoustic potential of sugarcane wasted fibers at different thickness using impedance tube tests. It was divided into four key stages: material preparation, pre-treatment, fabrication and testing.

#### 3.1 Material Preparation

This research used sugarcane waste fibre, as the primary ingredient to create the sustainable sound-absorbing samples. Gypsum was added as a binder and a bio-adhesive is used to provide stronger bonding between the fiber and gypsum. Raw materials are gathered from nearby vendors and brought to the laboratory to undergo several processes. The sugarcane bagasse was ground into small pieces (5–10 mm) using a hammer mill. Fibers are sieve using a table shaker and only the cut fibres that made it through a 3 mm sieve were chosen for the next processing stages. The important of this process is to ensure the uniformity in particle size when mixed with gypsum and bio-adhesive, which is essential for both mechanical strength and acoustic performance. The gypsum was purchased commercially and was selected due to its appropriate chemical composition and quick-setting qualities. In the meantime, the bio-adhesive which is a natural and environmentally responsible substitute for synthetic glues that able to give better bonding between fibres and gypsum.

#### 3.2 Pre-treatment

The pre-treatment stage of this study on utilizing sugarcane bagasse for sound absorption is crucial for optimizing its acoustic properties. Firstly, the preparation of materials in implementing this study is very necessary because this material is the key to ensuring this study succeeds. The material consists of sugarcane waste fiber, which is the main character of this study, with gypsum and bio-adhesive. The initial step involved cutting the raw bagasse into small pieces using a hammer mill, which facilitates processing and uniformity. Following this, the cut material was sieved to ensure consistent particle size, a factor vital for effective sample distribution and improved binding during subsequent processing stages. Next, the sieved bagasse underwent hot water pre-treatment to eliminate impurities such as sugars and proteins. This step enhances the purity of the material and prepares it for better binding capabilities [16]. Afterward, washing further removed residual impurities from the treated bagasse. The final pre-treatment phase involved sun drying followed by oven drying over one week to eliminate moisture completely. This meticulous process ensures optimal binding and maximizes acoustic performance when combined with gypsum binder and bio-adhesive. Figure 1 shows the two main materials used in this study.



**Fig. 1** (a) Sugarcane bagasse; (b) Gypsum powder

### 3.3 Fabrication

The fabrication process of sound absorption samples using sugarcane bagasse is meticulously designed to achieve optimal acoustic performance and structural integrity, targeting a density of  $600 \text{ kg/m}^3$  [17]. The initial stage involves material preparation, where sugarcane bagasse is combined with gypsum binder and bio-adhesive in a 3:1 weight ratio. This specific ratio is critical as it balances sound absorption capabilities with mechanical strength, laying the groundwork for effective sample fabrication [18]. Following material preparation, mixing occurs, where the components are manually mixed with water to ensure uniform distribution before being poured into rounded moulds with diameters of 28 mm and 100 mm. This mould design aids in achieving consistent material distribution, which is essential for good acoustic quality across various frequency ranges. The next step entails cold pressing the filled moulds for a duration of one day, which compacts the mixture and creates the smooth surface necessary for attaining precise thicknesses of either 30 mm or 50 mm. After the cold press process, the samples are carefully unmounted to retain their shape and dimensions crucial for subsequent impedance tube testing. The next step involves curing the samples in a controlled environment to further enhance their structural integrity. This comprehensive fabrication process produces high-quality sound absorption samples from sugarcane bagasse, preparing them for rigorous acoustic analysis. Figure 2 shows the fabrication of the sample.



**Fig. 2** (a) Molding sample; (b) Cold press; (c) Raw sugarcane bagasse sample

### 3.4 Testing

Sound absorption performance testing is a critical process for evaluating how effective the materials and structures absorb sound energy. In this study, the impedance tube is used to determine the sound absorption coefficient of sound absorbers. The impedance tube test was conducted according to BS EN ISO 10534-2:2001, ensuring reliable results [19]. Key parameters measured include the Sound Absorption Coefficient ( $\alpha$ ), which

indicates the proportion of absorbed sound energy and varies with frequency, leading to additional metrics like the Noise Reduction Coefficient (NRC) providing broader insights into material performance across various frequencies. The AFD 1001-Acousti Tube software is used to analyze the sound absorption coefficients between 125 Hz to 5000 Hz frequencies.



**Fig. 3** Impedance tube test

Figure 3 shows the impedance tube used in this study. The procedure for impedance tube testing is a systematic approach used to determine the acoustic properties of materials, particularly their sound absorption capabilities. Firstly, the noise generator was connected to a power amplifier, which serves as the energy source for driving the loudspeaker situated within the impedance tube. Subsequently, the power amplifier is linked to a loudspeaker in the impedance tube, creating an environment where sound waves can propagate effectively. Following this, condenser microphones are screwed onto amplifiers to capture sound data accurately. These microphones play an essential role in measuring the acoustic response of the sample that is tested. Once connected, preamplifiers are linked to a frequency analyzer that processes and displays frequency response functions. The next steps involve inserting the sample into the tube while ensuring proper alignment with reference tubes. This alignment is vital for obtaining accurate measurements of sound absorption. After securing the sample with screws, detailed information about its specifications has been inserted into analysis software. With all connections established and configurations set correctly, operators have been turned on for both the generator and amplifier, and the software is ready to be run. Frequency response functions are then obtained at varying frequencies. Then, the results of the SAC and graph for each frequency are shown in the software. Finally, the test is repeated for other samples and to another diameter.

## 4. Results and Discussions

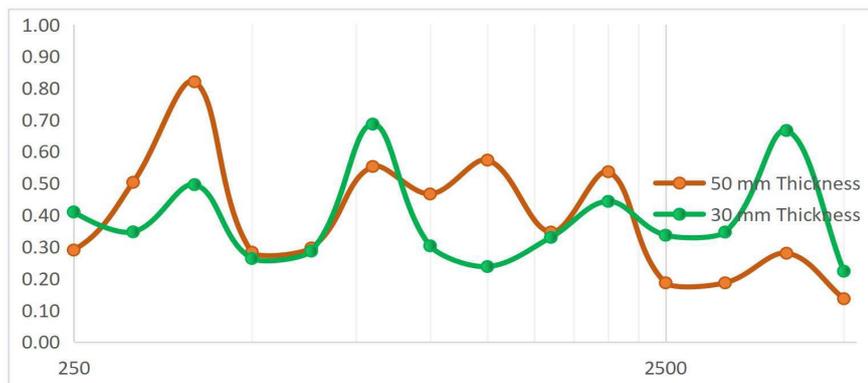
This section provides the findings and discussions related to the acoustic characteristics of sugarcane bagasse composites, with a special focus on their noise reduction coefficients as well as their ability to absorb sound. Sound absorption coefficients (SAC) at different thicknesses, 30 mm and 50 mm, are investigated to provide significant details about how well the material reduces sound at various frequency ranges. Their performance will be demonstrated by comprehensive tables and figures, highlighting the promise of these composites as environmentally friendly substitutes for traditional sound-absorbing materials. The discussion will also address the implications of material thickness for sound absorption efficiency, providing a nuanced understanding of how these composites can be optimized for specific acoustic applications. This research was focused on the application of the absorber at low frequency and high frequency. The low frequency range is 160 Hz to 2500 Hz, and the high frequency range is 2500 Hz to 6300 Hz. Thus, the samples tested were fabricated in 100 mm and 28 mm diameters with the variation of thickness, which is 30 mm and 50 mm. Analysis was done on each sample, and data were averaged based on thickness to ensure accurate results could be obtained.

### 4.1 Sound Absorption Coefficient of 30 mm and 50 mm Thick Sugarcane Bagasse Panel at Different Thickness

As shown in Table 2, the average Sound Absorption Coefficients (SAC) for 30 mm and 50 mm thick samples are display at octave frequencies. Graphical analysis of the data as shown by Figure 4 illustrates the sound absorption coefficient (SAC) based on samples thickness reveals significant differences in acoustic performance. Increased thickness generally correlates with enhanced sound absorption, highlighting the potential of sugarcane as an effective sustainable material for acoustic applications [11].

**Table 2** Average sound absorption coefficient for 30 mm and 50 mm thickness using octave band frequencies

Frequency (Hz)	Sound Absorption Coefficient ( $\alpha$ )	
	Sample (30mm)	Sample (50 mm)
160	0.49	0.69
200	0.57	0.29
250	0.41	0.29
315	0.35	0.50
400	0.50	0.82
500	0.26	0.28
630	0.29	0.30
800	0.69	0.55
1000	0.30	0.47
1250	0.24	0.57
1600	0.33	0.35
2000	0.44	0.54
2500	0.34	0.19
3150	0.35	0.19
4000	0.67	0.28
5000	0.22	0.14
6300	0.25	0.19

**Fig. 4** Average sound absorption coefficient against frequency for 30 mm and 50 mm thickness

Both the 30 mm and 50 mm thickness samples exhibit a generally similar trend, where SAC initially increases with frequency before reaching a peak and subsequently decreases. This pattern suggests that as frequency increases, the materials become more effective at absorbing sound up to a certain point, after which their effectiveness diminishes. Such behaviour highlights the importance of selecting the appropriate material thickness for specific acoustic applications [20]. When analyzing the peak SAC values, it was shown that the 50 mm thickness demonstrates superior performance compared to its 30 mm counterpart. The higher peak SAC observed at lower frequencies indicates that thicker materials are more proficient in sound absorption at these frequencies. Thicker absorbers are particularly effective at lower frequencies, which have longer wavelengths and require more material to be effectively absorbed. Thinner absorbers may be sufficient for higher frequencies but will struggle with lower ones.

Meanwhile the 50 mm thickness excels at absorbing lower frequencies, it appears less effective at higher frequencies compared to the 30 mm thickness. Conversely, the thinner material exhibits improved absorption capabilities at elevated frequencies. This differential response highlights the necessity of considering both material characteristics and application-specific requirements when designing sound-absorbing solutions [12]. Based on the results, it can be stated that a sound-absorbing sample's thickness has a big impact on how well it absorbs sound at different frequencies. Lower frequencies are often better absorbed by thicker samples, whereas higher frequencies are better absorbed by thinner samples. This phenomenon is consistent with the ideas presented by a number of studies on material qualities and sound absorption coefficients (SAC) [21]. According

to the correlation between thickness and frequency response, these properties should be taken into account when designing acoustic materials in order to maximize sound absorption in particular settings [11].

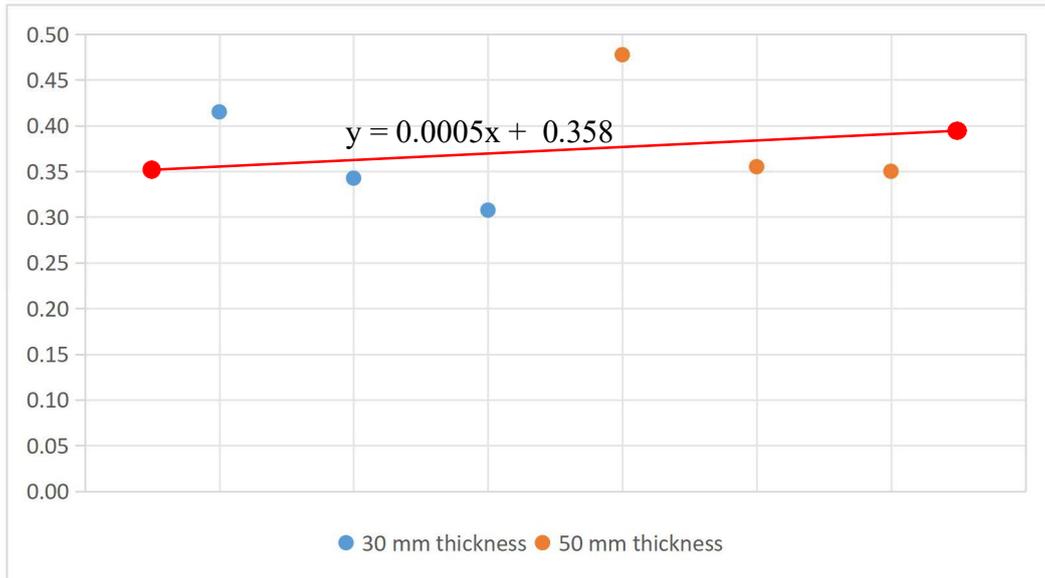
The results demonstrate that the thickness of the material has a significant impact on the absorption of sound at various frequencies. The pattern for samples that are 30 mm and 50 mm thick is similar: sound absorption rises with frequency until it peaks, after which it falls. However, because the 50 mm sample can absorb longer wavelengths more efficiently, it performs better at lower frequencies. At higher frequencies, however, where thinner materials tend to be more responsive, the 30 mm sample performs better. This contrast emphasises how crucial it is to match the target frequency range and material thickness in acoustic design. While thinner materials work better for high-frequency applications, thicker materials are best for controlling low-frequency noise. In the end, the secret to maximising sound absorption for particular environments is selecting the appropriate thickness.

#### 4.2 Noise Reduction Coefficient

Table 3 indicates that the Noise Reduction Coefficient (NRC) of sugarcane fibre composites increases with thickness, particularly showing notable improvements in the low-frequency range [20]. Figure 5 displays the NRC value for each sample. It shows that the sample with a 50-mm thickness got a higher NRC value than the sample with a 30- mm thickness. One key reason thicker materials exhibit higher NRC values is their increased ability to absorb sound. As the thickness of a material increases, the distance sound waves must travel within it also lengthens. This extended path length allows more sound energy to be dissipated through the material, leading to more efficient absorption. Consequently, the thicker a material is, the more sound energy it can absorb, enhancing its overall NRC [22]. Additionally, the Noise Reduction Coefficient (NRC) indicates that thicker samples generally provide superior noise reduction compared to the thinner sample. One important indicator of how well acoustic materials work to lower noise levels in a room is the NRC. Sounds in this range, such as bass and low rumbling noises, have longer wavelengths that require more mass to effectively absorb. According to [23], thicker panels with lower gas flow resistivity are especially good at reducing low-frequency noise, which is crucial for settings where low-frequency noise can be an issue, such as recording studios or public spaces. To get the intended acoustic results, choosing the right material thickness becomes crucial.

**Table 3** Noise reduction coefficient at 30 mm and 50 mm thickness

Frequency \ Thickness	0.44	0.32	0.31	0.59	0.42	Average
<b>30</b>	0.44	0.32	0.31	0.59	0.42	0.36
	0.44	0.21	0.21	0.51	0.34	
	0.35	0.26	0.39	0.23	0.31	
<b>50</b>	0.47	0.40	0.46	0.58	0.48	0.39
	0.25	0.18	0.46	0.53	0.36	
	0.15	0.27	0.48	0.50	0.35	



**Fig. 5** Noise Reduction Coefficient at 30 mm and 50 mm thickness

The Noise Reduction Coefficient (NRC) is a critical measure that quantifies a material's sound absorption capabilities, averaged across specific frequencies: 250 Hz, 500 Hz, 1000 Hz, and 2000 Hz. Understanding the relationship between NRC and material thickness is vital for various applications, ranging from architectural design to acoustical engineering. For instance, samples with thicknesses of 30 mm and 50 mm demonstrate this trend, with 50 mm samples generally exhibiting superior sound absorption capabilities. The NRC value is calculated using formula as shown in Equation 1.

$$NRC = \frac{\alpha_{250} + \alpha_{500} + \alpha_{1000} + \alpha_{2000}}{4} \tag{1}$$

### 5. Conclusion

This study showed that sugarcane bagasse have significant potential as a sound-absorbing material. By testing samples of different thicknesses 30 mm and 50 mm, it was found that both samples absorbed sound well, especially in the 400 to 4000 Hz range. The thicker 50 mm samples performed better at lower frequencies, while the thinner samples were more effective at higher frequencies. Moreover, the thicker samples achieved a higher Noise Reduction Coefficient (NRC) of 0.39, which, although lower than expected, but considerably useful for specific soundproofing applications, especially in low-frequency environments. Overall, the results highlight the importance of choosing the correct thickness depending on the type of frequency that needs to be absorbed. Finally, it can be concluded that sugarcane bagasse is an eco-friendly option for acoustic applications.

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### Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

### Author Contribution

*The authors are responsible for the study conception, research design, data collection, data analysis, result interpretation and manuscript drafting.*

### References

[1] Chen, W., Cao, H., Hu, S., Huang, T., Wu, X., Lu, L. & Peng, J. (2019). Review on research process of sound reduction materials. *Material Science and Engineering*, 612(5). pp 52-62

- [2] Tang, X. & Yan, X. (2017). Acoustic energy absorption properties of fibrous materials. *Applied science and manufacturing*, 101. pp 360-380
- [3] Singh, M., & Gupta, M. (2020). Sound absorption properties of natural fibers. *Materials*, 12(20). 348
- [4] Abatan, A., Lottu, O., Ugwuanyi, E.D., Jacks, B.S., Sodiya, E.O., Daraojimba, A. & Obaigbena, A. (2024). Sustainable packaging innovation and their impact on HSE practices in the FMCG industry. *Magna scientia advanced research and review*, 10(1). pp 379-391
- [5] Morsy, M. S., Alsayed, S. H., & Salloum, Y. A. (2012). Development of eco-friendly binder using metakaolin-fly ash-lime-anhydrous gypsum. *Construction and Building Materials*, 35, pp 772-777.
- [6] Duan, H., Shen, X., Yang, F., Bai, P., Lou, X., & Li, Z. (2019). Parameter optimization for composite structures of microperforated panel and porous metal for optimal sound absorption performance. *Applied Sciences*, 9(22), 4798.
- [7] Xu, Q., Ji, Tao., Gao, S.J., Yang, Z., & Wu, N. (2019). Characteristics and applications of sugar cane bagasse ash waste in cementitious materials. *National library of medicine*, 12(1). pp 39
- [8] Mehrzad, S., Ebrahim, T., Soltani, P., Samaei, S.E. & Khavanin, A. (2022). Sugarcane bagasse waste fibers as novel thermal insulation and sound-absorbing materials for application in sustainable buildings. *Building and environment* 211(1).
- [9] Hassan, T., Jamshaid, H., Mishra, R., Khan, M.Q., Petru, M., Tichy, M. & Muller, M. (2021). Factors affecting acoustic properties of natural-fiber-based materials and composites: a review. *Textiles*, 1(1). pp. 55-85
- [10] Rozli, S.R. & Azmir, N.A. (2020). The study on acoustic properties of sugarcanebagasse as sound absorber. *Advanced research in natural fibers*, 2(1). pp. 5-9
- [11] Malawade, U.A. & Jadhav M.G. (2020). Investigation of the acoustic performance of bagasse. *Materials research and technology*, 9(1). pp. 882-889
- [12] Taban, E., Khavanin, A., Ohadi, A., Putra, A., Jafari, A.J., Faridan, M. & Soleimanian A. (2019). Study on the acoustic characteristics of natural date palm fibres: Experimental and theoretical approaches. *Building and environment*, 161(1).
- [13] Haghihat, M., Samaie, S. E., Amininasab, S., Faridan, M., Mehrzad, S., Sheikhmozafari, M. J., & Ebrahim, T. (2023). Enhancing sound absorption in micro-perforated panel and porous material composite in low frequencies: A numerical study using FEM. *Sound & Vibration*, 58(1)
- [14] Ewe, L.S., Kean, Y.W., Woon, S.H. & Zawawi. (2023). Sound absorbing material based oil palm frond natural fibers. *Sains Malaysiana* 7(52). pp 2103-2114.
- [15] Samaei, S.E., Berardi, U., Taban, E., Soltani, P. & Mousavi, S.M. (2021). Natural fibro-granular composite as a novel sustainable sound-absorbing material. *Applied acoustic*, 181(1)
- [16] Moura, A., Bolba, C., Demori, R., Lima, L., & Santana, R. (2018). Effect of Rice Husk Treatment with Hot Water on Mechanical Performance in Poly(hydroxybutyrate)/Rice Husk Biocomposite. *Journal of Polymers and the Environment*, 26, 2632-2639.
- [17] Zhao, Z., Li, X., Jiang, H., Su, X., Zhang, X., & Zou, M. (2023). Study on the mechanical properties and energy absorbing capability of polyurethane microcellular elastomers under different compressive strain rates. *Polymers*, 15(3), 778.
- [18] Vetrivel Kumar, K., Manikanda Prabu, N., Jayanthi, M., & Gurusamy, S. (2024). Synthesis and characteristics of natural fiber reinforced nano hybridcomposite—an experimental study. *International Journal of Materials Research*, 115(9), 722-733.
- [19] Duris, R., & Labasova, E. (2021). The design of an impedance tube and testing of sound absorption coefficient of selected materials. *IOP Conference Series: Materials Science and Engineering*, 1050.
- [20] Mohammadi, M., Taban, E., Tan, W. H., Din, N. B. C., Putra, A., & Berardi, U. (2024). Recent progress in natural fiber reinforced composite as sound absorber material. *Journal of Building Engineering*, 108514.
- [21] Peng, L. (2017). Sound absorption and insulation functional composites. In *Advanced high strength natural fibre composites in construction* (pp. 333-373). Woodhead Publishing.
- [22] Cox, T., & d'Antonio, P. (2016). *Acoustic absorbers and diffusers: theory, design and application*. CRC press.
- [23] Yang, J., Lee, J., Lee, H., Kang, Y., & Kim, Y. (2018). Slow-wave metamaterial open panels for efficient reduction of low-frequency sound transmission. *Applied Physics Letters*, 112, 091901.