International Journal of Technology 15(3) 618-627 (2024)
Received April 2023 / April 2023 / Accepted July 2023

International Journal of Technology

Study on Nature Fiber Composite for Noise Material Control

Muhammad Zulkarnain[1*], Irianto Harny[2], Mohamad Irfan Insdrawaty[1], Mohamad Izmul Farees Azman[1], Muhamad Izwan Aiman Azmi[1], Eny Kusrini[3,4,5]

[1]Faculty of Mechanical Technology and Engineering, *Universiti Teknikal Malaysia Melaka (UTeM), 76100 Durian Tunggal, Melaka, Malaysia*
[2]*Department General Education, Faculty of Resilience, Rabdan Academy, 22401 Abu Dhabi, United Arab Emirates*
[3]*Department of Chemical Engineering, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI, Depok 16424, Indonesia*
[4]*Research Group of Green Product and Fine Chemical Engineering, Laboratory of Chemical Product Engineering, Department of Chemical Engineering, Universitas Indonesia, Kampus Baru UI, Depok, 16424, Indonesia*
[5]*Tropical Renewable Energy Research Center, Faculty of Engineering, Universitas Indonesia, Kampus Baru UI, Depok, 16424, Indonesia*

Abstract. Transportation tracks of railways and highways are the highest noise pollution contribution to the inhabitant urban due to the sources near residential areas. Many researchers proved that the composite material could help reduce the noise by 30%. This study focuses on designing local nature fiber composite for developing a good sound absorption material by providing experimental methods. Three natural fibers of coconut, palm oil, and sugarcane are used to make a composite by varying filler content for sound absorption and transmission loss observation. The results found that sugar cane bagasse is suitable for average performance in varied filler content for both sound absorption and transmission loss. The overall results showed a successful improvement in both sound absorption coefficient and transmission loss with the addition of fiber content.

Keywords: Absorption coefficient; Environmental noise; Noise barrier; Natural fiber; Transmission loss

1. Introduction

The capital cities with modern facilities generate numerous sources of noise pollution in their surroundings, including vehicles, high-speed railways, industries, and construction activities. These factors directly impact the urban inhabitants. The drawback effects of environmental noise are shown in the form of mental health, high stress, or high sound pressure environments that propose hearing damage permanently. Many researchers have shown that this pollution impacts the quality of life by receiving regularly and continuing as an annoying source (Yu *et al*., 2023; Guha *et al*., 2023; Ciach *et al*., 2019). Comprehensive scientific studies have presented methods to counter or reduce the adverse effects of noise pollution. In transportation, efforts to reduce noise pollution were popular by introducing composite material based on the railway structure (Gu *et al*., 2022; Zhang *et al*., 2022). The noise from railway vibration is absorbed by structure-borne concrete composite bridges

*Corresponding author's email: m.zulkarnain@utem.edu.my, Tel.: +60124418174; Fax: +6062701039
doi: 10.14716/ijtech.v15i3.6442

and composite floors. In this research, the composite is a paramount part of reducing the noise to 30% as reported.

In urban management, it has been reported that rice husk nanoparticle composites effectively mitigate the reverberation effect around building facades caused by noise. The composite generated tends to have a high absorption material that is denoted by increasing the sound absorption coefficient of materials (Rendón *et al.*, 2023; Sharma *et al*. 2023; Raj *et al*., 2020; Hassan *et al.*, 2020; Echeverria *et al*. 2019; Samodra, 2018). They observed that the relation between the particle size of the filler and sound absorption coefficient levels was affected. The natural source to generate composite becomes one alternative to reduce pollution, a significant study has been made by utilization of bamboo biochar as a filler in natural rubber composite for vibration and noise control (Mago *et al.*, 2022; Khair *et al.* 2015). However, there are several materials the most widely used to absorb vibrations and noise pollution in some engineering applications such as rubber (Corredor -Bedoya, Zoppi, and Serpa, 2017), wool (Ilangovan *et al*., 2022), and silica (Yusoff *et al*., 2023) to optimize a material design. Natural fibers are well-known in engineering applications due to their present advantages, such as no harmful emissions and, at the same time, being able to compete with the mechanical performance capabilities of synthetic materials. Additionally, certain natural fibers are local commodities, representing renewable resources throughout every season (Operato *et al*., 2023).

The study of the absorption material is required, and the relation between material and sound absorption coefficient and overall performance is to be well understood through the properly designed material. The optimization of design will promote the prevention of noise from the source and provide well on transmission loss of sound. Many studies have proposed different optimization strategies to control the noise system for material design. First, through the experiments, the material design is characterized by measurement testing and analyzed for the sound transmission characteristics of the composite (Zhang *et al*., 2022; Zheng *et al*., 2022). Secondly, numerical studies, such as finite element analysis, are employed to optimize and validate the transmission loss and vibration through composite materials (Lim, Yaw, and Chen, 2022; Araújo and Madeira, 2020; Soltani *et al*., 2020). These studies have indicated that optimized design can play a crucial role in mitigating the spread of noise contaminants and enhancing acoustical contributions.

Generally, natural fibers are difficult to harvest directly to be a composite due to natural fibers having a lot of impurities naturally (Yudha *et al.*, 2023; Indrasti *et al*., 2020; Hariprasada *et al.,* 2020). A special investigation is required to determine the feasibility of natural fiber treatment (Dasore *et al*., 2022). The previous researcher reported that varied levels of alkalinity were observed in composite strength through morphological improvement (Suwan *et al*., 2021). On the other hand, fiber size process conditions affect composite performance on mechanical, thermal, or sound absorption coefficient itself. The previous researcher reported that thermal stability is more efficient by adding composites reinforced with nano clay (Choudhary *et al*., 2023), and chrome shave (CS) and coffee silver skin (CSS) fiber composite showed slightly higher sound absorption performance of 1 mm compared to 3 mm of size (Abdi, 2021).

Realizing the importance of using local nature fibre regarding optimization material design on mitigating noise contaminants, this study focuses on designing local nature fiber composite for developing a good sound absorption material by providing experimental methods. Characteristics of natural fibers such as coconut, palm oil, and sugarcane on sound absorption coefficient and transmission loss are proposed in this investigation. The optimization of material design is characterized by varying filler content with the polyester matrix. This composite material is targeted as a noise barrier for high-noise transportation tracts close to residential areas, such as near railway traffic noise (Zheng *et al.*, 2022; Abdulkareem *et al.*, 2021) and highways (Shokouhian *et al.*, 2021).

2. Methods

2.1. Materials

Matrix composite is polyester resin and is a viscous liquid resin made from glycol and unsaturated dibasic acid condensate, and the hardener is the butanox m-50 with a ratio of 100:4. Another chemical is the solution of sodium hydroxide (NaOH) for cotton yarns or fabrics. Three natural fibers, namely coconut, palm oil, and sugarcane, are employed to create a composite. The ratio of composite with varied filler content detail is given in Table 1.

Table 1 Ratio of composite detail with varied filler content

Polyester Weight (g)	Hardener Weight (g)	Fibre Weight (g)	Total Weight (g)	Fibers Percentage (%wt.)
336.00	14.00	0.00	350	0
329.28	13.72	7.00	350	2
322.56	13.44	14.00	350	4
315.84	13.16	21.00	350	6
309.12	12.88	28.00	350	8
302.40	12.60	35.00	350	10
295.68	12.32	42.00	350	12

2.2. Natural Fibres Collection

The natural fiber of coconut, palm oil, and sugarcane were collected from local sources by varying methods. The coconut fibers were made from the coconut skin received from local farmers in Malaysia, and they were then shredded to get the coconut fiber before any treatment was conducted. The coconut fiber was then cleaned with distilled water and dried for one day in direct sunlight. Moreover, the oil palm fiber was made from oil palm fruits and collected from the palm oil industry in Malaysia after the milking process. Meanwhile, the leftover components, which are typically referred to as bagasse, were generated as by-products after the sugar canes were compressed. Due to the bagasse containing a lignocellulose substance made up of 45–55 percent cellulose and 25–30 percent hemicellulose, the natural sugarcane fiber was submerged in water for 24 hours to remove those impurities. To prevent the sugarcane from remaining in moisture conditions, the sugarcane residue was exposed to the sun to evaporate the water.

2.3. Mercerization Processing

To enhance flexibility and remove impurities from the natural fiber, it underwent treatment with a 2% sodium hydroxide (NaOH) solution, commonly referred to as an alkaline treatment. The natural fibers were submerged for a predetermined period of time at a predetermined temperature in a NaOH solution, as shown in Figure 1a. Subsequently, the fibers were thoroughly rinsed to remove the solution, using distilled water. In addition, the coconut fiber was soaked for 1 to 2 hours in distilled water to neutralize it and render it non-alkaline. Followed by an evaporation stage where the fibers were dried in the oven at 100^{o}C for six hours as shown in Figure 1b.

Figure 1 Natural fiber treatment; 1a) NaOH immersing and 1b) dried process

2.4. Composite Preparation

The process of removing impurities involved a grinding and sifting process in the preparation of the material. In the sieving process, the fibers were filtered to remove unwanted materials such as cotton on sugar cane fiber and palm oil shell fragments from the fiber, as shown in Figure 2a. The preparation of the composite material ratios followed the guidelines outlined in Table 1. The mold used in the process was crafted from a steel plate with a thickness of 5 mm. The ease-release compound was required to be applied to the mold before pouring the polyester inside. The composite was made by implementing the lay-up technique, where the polyester was mixed with the hardener before being applied to the mold together with the fibers. The composite curing was at ambient temperature for 4 hours, followed by cutting the sample using a hole saw 38 mm in diameter for each sample, as shown in Figure 2b.

(a) **(b)**

Figure 2 (a) Impurities removal processing, (b) Composite samples were analyzed in the impedance tube

2.5. Impedance Tube Testing

The impedance tube with ACUPRO Version 4.5 was used to measure the acoustical properties of materials and systems under ISO 10534–1 (ISO, 2002) and ASTM E2611 for transmission loss measurement. The ACUPRO tube with supports and leveling screws was made of stainless steel with an internal diameter of 38 mm. The operating range frequency level ranged from 50 Hz to 5000 Hz with 4 microphones. The impedance tube was measured for both sound absorption coefficient and transmission loss of those frequency ranges.

3. Results and Discussion

3.1. Noise Absorption Coefficient

The plotting graph was described as a single peak to measure the sound absorption coefficient of each sample. Figure 3 presents the level of the sound absorption coefficient against the frequency of coconut fiber. The observation of the sound absorption coefficient was conducted by varying the filler content within the range of 0% wt. to 8% wt. Likewise, the frequency absorption has shown in diversity ranges. Based on the results, the 6%wt. of filler content showed a slightly higher sound absorption coefficient compared to others reaching 0.985, while 0.832 was the lowest reached by the polyester. It means that the sound absorption coefficient was close to 1 and has an improvement of around 16.62% compared to polyester. Other observations found that the frequency absorption values occur at 2268 Hz presented that early compared to other composite filler content. This frequency was valid and good results were expected for the frequency ranges between 45 $45.6 \leq f \leq 4559$ Hz and $64.8 \leq f \leq 6480$ Hz for coconut and sugar cane, respectively (Da-Silva *et al.*, 2019). While the sound absorption factor for each palm oil sample is illustrated in Figure 4. The single peak predicted that the highest peak occurred in 8% by Weight. of filling content observed that all peaks resulted below 3300 Hz. By comparing the initial sound absorption coefficient of polyester, it has improved by 20.12% from the polyester shown much better than coconut fiber. Another observation has been done on sugar cane fiber composite. The sugar cane fiber also reported showing good agreement with adding filler content which is the highest single peak shown by 10% wt. of filler content as shown in Figure 5. It reported that a wide range of frequencies at a single peak occurs from 3000 Hz to 3900 Hz.

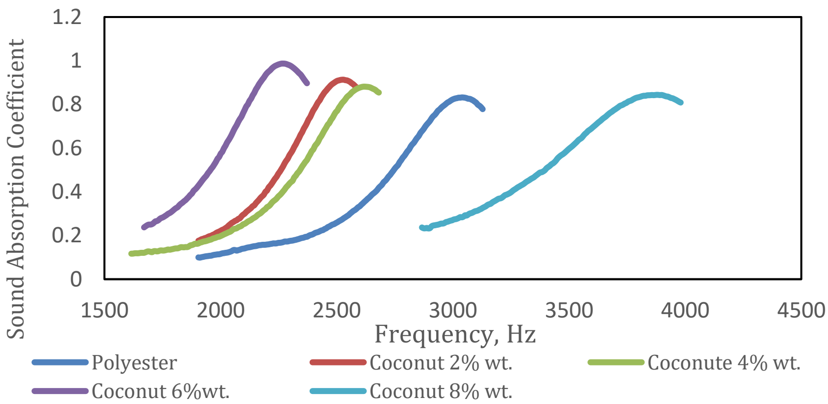

Figure 3 The sound Absorption coefficient against the frequency of Coconut Fiber

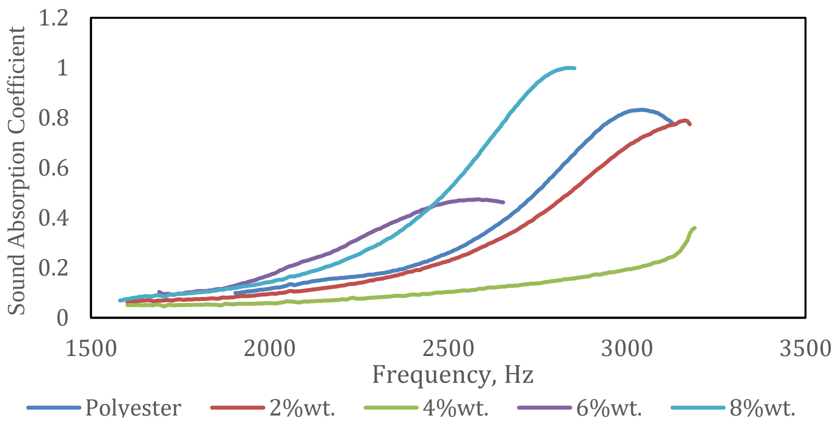

Figure 4 The sound Absorption coefficient against the frequency of Palm Oil Fiber

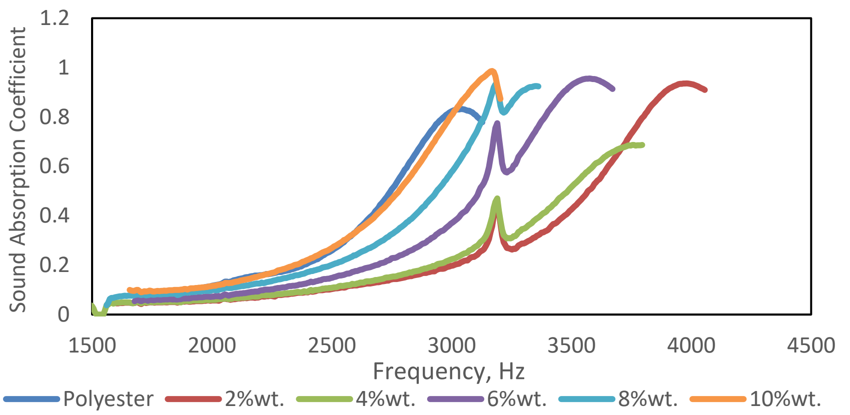

Figure 5 The sound Absorption coefficient against the frequency of sugar cane fiber

All results present the phenomenon of the sound absorption coefficient being linear to fiber content. These measurements were the average absorption graphs mentioned in Figure 6. The potential of coconut composite to sound absorption was successful and obviously shown good based on the results. In the observation of filler content, the sound absorption coefficient of oil palm fiber exhibited a slight linear increase, as depicted by the average plotting on the graph, albeit on a small scale. Furthermore, the sugar cane results also presented performance improvement in sound absorption by linearly adding sugar cane fiber. This improvement was able to achieve a sound absorption percentage increase average of 18.54% compared to pure polymer.

The comparison of the sound absorption coefficient for all natural fibers is shown in Figure 7. The high performance was shown by palm oil fiber at 20.12% from pure polyester. It is obvious that natural fiber has the potential to absorb sound to control the noise system. This phenomenon was also reported by previous researchers, and natural fiber was successfully used as an alternative material for noise control (Saini *et al.*, 2020; Kesharwani *et al*. 2020; Sasikumar *et al.,* 2020; Da-Silva *et al.*, 2019).

3.2. Transmission Loss Measurement

On the ACUPRO impedance tube, ASTM E2611 stated two load methods for transmission loss measurements, first by using Anechoic Load A for independent termination of the tube and second by using Rigid Load B. This investigation was represented by Rigid Load B to describe transmission loss conditions for each natural fiber composite. The ability of the material to absorb the sound can be observed by plotting the graph between sound (dB) and filler contact (%wt.). Figure 8 shows the transmission loss that occurs in the all-natural fiber composites obtained by predictions by DB. The coconut can be seen obviously that the sound (dB) successfully counters by the composite denoted by linear line by increasing the filler content (%wt.). It can be verified that the values of the transmission loss increase by adding filler content. With the comparison of the results from palm oil fiber, it is easy to observe that the optimization of the palm oil fiber composites some meet unsuccessful. The results found that only 2%wt. of filler content showed higher absorbance of the sound (dB) then became constantly lower. It might have been caused by inhomogeneous fiber distribution and agglomeration during composite fabrication. A good agreement between transmission loss and filler content was shown by sugar cane fiber that filler content succeeds in countering the sound by adding the fiber. According to the results, coconut fiber was the best combination of the transmission loss composite material, giving the most effective sound absorption, as shown in Figure 9. All composites were collected at similar frequencies of transmission loss peaks of around 5000 Hz. It was confirmed by the results of previous research that found the transmission loss of coconut was higher due to good fiber distribution or well morphology and allowed to absorb more sound (Bhingare and Prakash, 2021; Da-Silva *et al*., 2019).

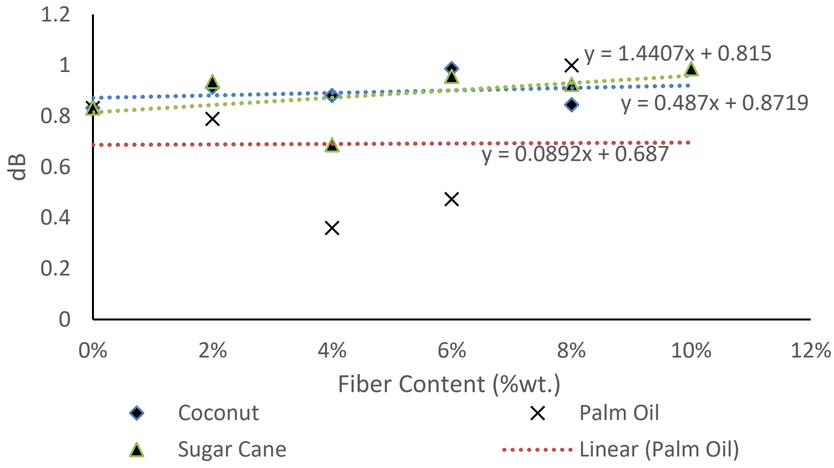

Figure 6 The sound absorption average of natural fiber

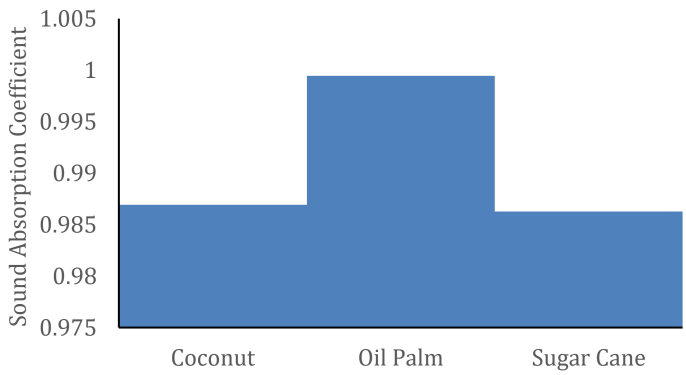

Figure 7 The sound Absorption coefficient of The natural fiber

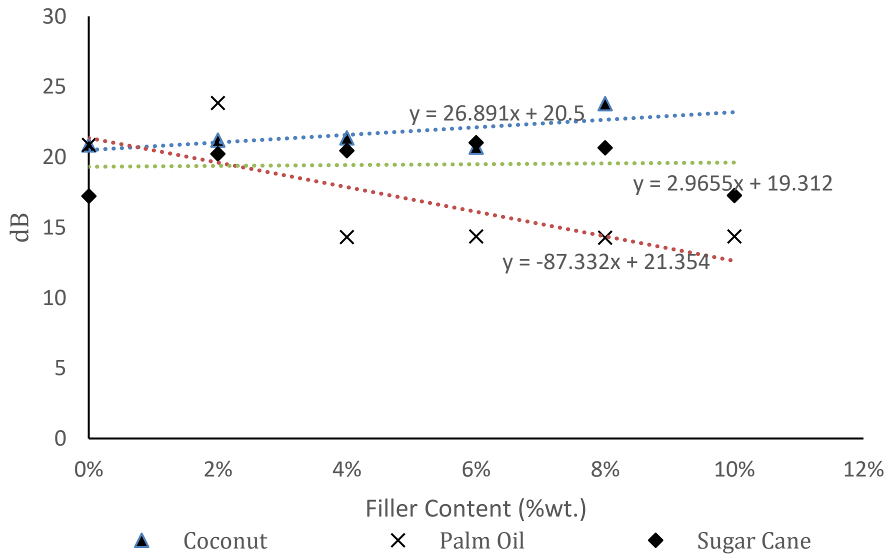

Figure 8 Transmission loss against filler content of natural fiber

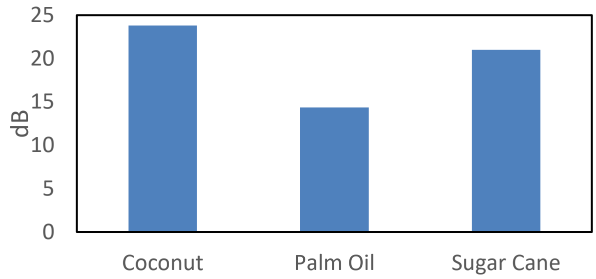

Figure 9 Transmission loss against natural fiber

4. Conclusions

The main target of this experimental study was to generate composite material based on natural fiber that presented good performance in noise control for noise barrier applications. Based on the observed results, several predictions have been formulated. The first suggests that the sound absorption coefficient obtained from oil palm exhibited superior performance. On the other hand, for overall average performance, sugar cane dominated, likely due to its promotion of low density and low stiffness. The second prediction indicates that the transmission loss of coconut fiber material surpassed that of other fibers, attributed to morphology-related factors. The sugar cane performance showed stable results on average compared to others which fluctuated. The third found that lay-up techniques of composite showed that it is very difficult to achieve the desired results due to the natural fiber presenting low density, which causes a lack of homogeneity of composite. However, the overall results showed an improvement in both sound absorption coefficient and transmission loss with the addition of fiber content. The last recommendation is to explore hybrid fiber content in noise control studies, aiming to address morphology issues by filling the void among fibers.

Acknowledgments

On behalf of all the authors, the corresponding author expresses profound appreciation to Universiti Teknikal Malaysia Melaka (UTeM) for the facilitative support provided by the laboratory, technicians, and all equipment during the completion of the research.

References

Abdi, D.D., Monazzam, M., Taban, E., Putra, A., Golbabaei, F., Khadem, M., 2021. Sound Absorption Performance of Natural Fiber Composite from Chrome Shave and Coffee Silver Skin. *Applied Acoustics*, Volume 182, p. 108264

Abdulkareem, M., Havukainen, J., Nuortila-Jokinen, J., Horttanainen, M., 2021. Life Cycle Assessment of A Low-Height Noise Barrier For Railway Traffic Noise. *Journal of Cleaner Production*, Volume 323, p. 129169

Araújo, A.L., Madeira, J.F.A., 2020. Multiobjective Optimization Solutions for Noise Reduction in Composite Sandwich Panels Using Active Control. *Composite Structures*, Volume 247, p. 112440

Bhingare, N.H., Prakash, S., 2021. An Experimental And Theoretical Investigation Of Coconut Coir Material For Sound Absorption Characteristics. *In:* Mater Today: Proceeding, Volume 43, pp. 1545–1551

Choudhary, S., Haloi, J., Sain, M.K., Saraswat, P., Kumar, V., 2023. Systematic Literature Review on Thermal and Acoustic Characteristics of Natural Fibre Polymer Composites for Automobile Applications. *In:* Materials Today: Proceedings, Volume 2023

Ciach, M., Faraś, H., Fröhlich, A., Fedyń, I., 2022. Contrasting Effects of Light and Noise Pollution Interact with Natural Vegetation Remnants: Human-Related Indicators Of The Habitat Suitability For Ungulates In The Urban Landscape. *Ecological Indicators*, Volume 142, p. 109261

Corredor-Bedoya, A.C., Zoppi, R.A., Serpa A.L., 2017. Composites of Scrap Tire Rubber Particles and Adhesive Mortar E Noise Insulation Potential. *Cement and Concrete Composites.* Volume 82, pp. 46–66

Da-Silva, C.C.B., Terashima, F.J.H., Barbieri, N., De-Lima, K.F., 2019. Sound Absorption Coefficient Assessment of Sisal, Coconut Husk and Sugar Cane Fibers For Low Frequencies Based on Three Different Methods. *Applied Acoustics*, Volume 156, pp. 92–100

Dasore, A., Rajak, U., Balijepalli, R., Verma, T.N., Ramakrishna, K., 2022. An Overview of Refinements, Processing Methods and Properties of Natural Fiber Composites. *In:* Materials Today: Proceedings, Volume 49, pp. 296–300

Echeverria, CA, Pahlevani F, Handoko W, Jiang C, Doolan C, Sahajwalla V., 2019. Engineered Hybrid Fibre Reinforced Composites For Sound Absorption Building Applications. *Resources, Conservation and Recycling,* Volume 143, pp. 1–14

Gu, Y.W., Nie, X., Yan, A.G., Zeng, J.H., Liu, Y.F., Jiang, Y.X., 2022. Experimental And Numerical Study on Vibration and Structure-Borne Noise of High-Speed Railway Composite Bridge. *Applied Acoustics*, Volume 192, p. 108757

Guha, A.K., Gokhale, S., 2023. Urban Workers' Cardiovascular Health Due to Exposure to Traffic-Originated PM2.5 and Noise Pollution in Different Microenvironments. *Science of the Total Environment,* Volume 859, p. 160268

Hariprasad, K., Ravichandran, K., Jayaseelan, V., Muthuramalingam, T., 2020. Acoustic and Mechanical Zcharacterization of Polypropylene Composites Reinforced by Natural Fibres for Automotive Applications, *Journal of Materials Research and Technology*, Volume 9(6), pp. 14029–14035

Hassan, T., Jamshaid, H., Mishra, R., Khan, M.Q., Petru M., Novak, J., 2020. Acoustic, Mechanical And Thermal Properties Of Green Composites Reinforced With Natural Fibers Waste. *Polymers (Basel)*, Volume 12(3), p. 654

Ilangovan, M., Navada, A.P., Guna, V., Touchaleaume, F., Saulnier, B., Grohens, Y., Reddy, N., 2022. Hybrid Biocomposites with High Thermal And Noise Insulation From Discarded Wool, Poultry Feathers, and Their Blends. *Construction and Building Materials*, Volume 345, p. 128324

Indrasti, N.S., Ismayana, A., Maddu, A., Utomo, S.S., 2020. Synthesis of Nano-silica from Boiler Ash in the Sugar Cane Industry using the Precipitation Method. *International Journal of Technology*, Volume 11(2), pp. 422–435

Kesharwani, A., Bedi, R., Bagha, A.K., Bahl, S., 2020. Experimental Study To Measure The Sound Transmission Loss Of Natural Fibers At Tonal Excitations. *In:* Materials Today: Proceedings, Volume 28, pp. 1554-1559.

Khair, F., Putra, A., Nor, M., Selamat, M., 2015. Enhancement On Acoustical Performance Of Feed 'Imperata Cylindrica. *In:* Proceeding Mech Eng Res Day, Volume 192(3), pp. 601–608.

Lim, C.W., Yaw, Z., Chen, Z., 2022. Periodic and Aperiodic 3-D Composite Metastructures with Ultrawide Bandgap for Vibration and Noise Control. *Composite Structures*, Volume 287, p. 115324

Mago, J., Negi, A., Pant, K.K., Fatima, S., 2022. Development of Natural Rubber-Bamboo Biochar Composites for Vibration and Noise Control Applications. *Journal of Cleaner Production*, Volume 373, p. 133760

Operato, L., Vitiello, L., Aprea, P., Ambrogi, V., de Luna, M.S., Filippone, G., 2023. Life Cycle Assessment of Poly(Lactic Acid)-Based Green Composites Filled With Pine Needles or Kenaf Fibers. *Journal of Cleaner Production*, Volume 387, p. 135901

Ouakarrouch M., Bousshine S., Bybi A., Laaroussi N., Garoum M., 2022. *Applied Acoustics*, Volume 199, p.109007.

Raj, M., Fatima, S., Tandon, N., 2020. A Study Of Areca Nut Leaf Sheath Fibers As A Green Sound-Absorbing Material. *Applied Acoustics,* Volume 169, p. 107490

Rendón, J., Giraldo, C.H., Monyake, K.C., Alagha, L., Colorado, H.A., 2023. Experimental Investigation on Composites Incorporating Rice Husk Nanoparticles for Environmental Noise Management. *Journal of Environmental Management*, Volume 325, p. 116477

Saini, M.K., Bagha, A.K., Kumar, S., 2020. Experimental Study to Measure The Transmission Loss Of Double Panel Natural Fibers. *In:* Materials Today: Proceedings*,* Volume 26, pp. 482–48

Samodra, F.X.T.B., 2018. Optimization of Architectural Electroacoustics Design for the Interior Mezzanines of Vertical Buildings. *International Journal of Technology*, Volume 9(2), pp. 246–256

Sasikumar, K.S.K., Saravanan, N., Sambathkumar, M., Guekndran, R., 2020. Acoustic Characterization Of Farm Residues For Sound Absorption Applications. *Materials Today: Proceedings*, Volume 33, pp. 2917–2922

Sharma, S., Sudhakara, P., Singh, J., Singh, S., Singh, G., 2023. Emerging Progressive Developments In The Fibrous Composites For Acoustic Applications. *Journal of Manufacturing Processes*, Volume 102, pp. 443–477

Shokouhian, M., Owolabi, O., Efe, S., Ikiriko, S., Tsegaye, T., 2021. Development of A Highway Geometry Based Noise Abatement Model. *Transportation Research Interdisciplinary Perspectives*, Volume 10, p. 100382

Soltani, P., Taban, E., Faridan, M,, Samaei, S.E., Amininasab, S., 2020. Experimental and Computational Investigation of Sound Absorption Performance of Sustainable Porous Material: Yucca Gloriosa Fiber. *Applied Acoustics,* Volume 157, p. 106999

Suwan, T., Maichin, P., Fan, M., Jitsangiam, P., Tangchirapat, W., Chindaprasirt, P., 2021. Influence of Alkalinity on Self-Treatment Process of Natural Fiber and Properties of Its Geopolymeric Composites. *Construction and Building Materials*, Volume 316, p. 125817

Yu, Y., Su, J., Jerrett, M., Paul, K.C., Lee, E., Shih, I.F., Haan, M., Ritz, B., 2023. Air Pollution and Traffic Noise Interact to Affect Cognitive Health in Older Mexican Americans. *Environment International*, Volume 173, p. 107810

Yudha, S.S., Banon, C., Falahudin, A., Reagen, M.A., Kaus, N.H.M., Salaeh, S., 2023. Fabrication of Silver-Silica Composite using the Carbo-thermal Degradation of Oil Palm Leaves for the Reduction of p-nitrophenol. *International Journal of Technology*, Volume 14(2), pp. 290–299

Yusoff, N.M., Lee, H.K., Ng, E.K., Rosli, N.S., Abdullah, C.A.C., Alresheedi, M.T., Mahdi, M.A., 2023. Titania-Coated Silica Nanocomposite For L-Band Noise-Like Pulse Fiber Laser. *Journal of Luminescence*, Volume 258, p. 119779

Zhang, J., Yao, D., Peng, W., Wang, R., Li, J., Guo, S., 2022. Optimal Design of Lightweight Acoustic Metamaterials for Low-Frequency Noise and Vibration Control of High-Speed Train Composite Floor. *Applied Acoustics*, Volume 199, p. 109041

Zheng, J., Li, X., Zhang, X., Bi, R., Qiu, X., 2022. Structure-Borne Noise of Fully Enclosed Sound Barriers Composed of Engineered Cementitious Composites on High-Speed Railway Bridges. *Applied Acoustics*, Volume 192, p. 108705