

Coconut Coir Fiber: An Innovative, Sustainable, and Decorative Material for Interior Soundproofing and Acoustic Design

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Abstract — Golden Fiber Acoustics: This research investigates the viability of coconut coir fiber as an innovative, sustainable, and decorative material for interior soundproofing and acoustic design. Traditional commercial sound absorbers, such as glass or mineral fibers, are often non-biodegradable and may pose health risks, spurring a demand for sustainable alternatives like natural fiber composites. The study focused on brown coir fiber due to its high strength, superior abrasion resistance, and elevated lignin concentration (approximately 45%). Specimens were fabricated using a hot press technique with a composition of 75% fiber and 25% starch, resulting in composites with varying thicknesses (6 mm, 6.8 mm, and 7.5 mm). Scanning Electron Microscopy (SEM) confirmed good bonding and the presence of porosity — an essential feature for acoustic performance. Acoustic testing revealed a direct correlation between thickness and performance, with the 7.5 mm thick samples demonstrating the highest and most consistent sound absorption. Furthermore, the orientation significantly mattered: Arrangement 2 (Natural Fiber toward the sound source) consistently exhibited superior and more stable sound absorption than Arrangement 1, especially at higher frequencies. This improved performance is attributed to the coir fiber's more porous structure, which allows sound waves to pass through and dissipate energy as heat. The market is ready for a coir acoustic panel but is cautious. The recommended commercial strategy is Performance-First, Design-Second, Sustainability-Always, leveraging the material's certified Noise Reduction Efficiency, Aesthetic Design, and features like Humidity Regulation to justify a premium price point.

Keywords—Coconut Coir Fiber; Natural Fibers; Sound Absorption; Acoustic Design; Sustainability; Porosity; Composite Material.

I. INTRODUCTION

Current commercial sound absorbers often rely on materials like glass or mineral fibers, which are non-biodegradable and, in some cases, are reasonably anticipated to be carcinogenic if inhaled, posing a risk to human health and the environment. This has spurred a movement in architecture and construction toward materials that offer a dual functionality of structural integrity and enhanced sound absorption while meeting sustainability goals. Natural fibers, such as flax, jute, hemp, and particularly coconut coir, have been extensively investigated as promising alternatives.

Bio-waste natural fibers are a growing, eco-friendly alternative to synthetic fibers, gaining traction in automotive, construction, and engineering as reinforcing materials. Their advantages include biodegradability, cost-effectiveness, high strength-to-weight ratio, and lower CO₂ emissions. While their

mechanical properties can be limited by factors like their hydrophilic nature, this can be improved through chemical treatments to enhance fiber-matrix adhesion. Among these, coir fiber is receiving significant attention due to its affordability and favourable properties.

This research is significant because it comprehensively analyses key properties of natural fiber composites, including thickness, density, porosity, air permeability, thermal conductivity, and sound insulation. Understanding these properties is crucial for tailoring the materials for effective sound absorption and thermal insulation, making them indispensable for practical, industrial applications. These materials are designed to address the noise path, offering a more feasible solution than treating the noise receiver. Coir composites are particularly novel, offering advantages over other bio-insulators such as low cost and good handling. The broader natural fiber composites also possess unique properties like recyclability, adaptability, and environmental safety.

II. MATERIAL AND METHODS

2.1. Extraction of Coir Fibers

The materials employed in this investigation encompass coir fibers, serving as the foundational elements for the fabrication of composites. Coir, derived from the husk of coconuts, distinguishes itself into two varieties: brown coir, sourced from fully ripened coconuts, and white coir. Brown coir, renowned for its heightened thickness, strength, and superior abrasion resistance, constitutes the focus of this study. Comprising approximately 44% cellulose and 45% lignin, along with 3% pectin and associated compounds, alongside a 5% water content, coir fibers exhibit a robust constitution. The elevated lignin concentration contributes to its rigidity and durability, rendering it a preferred choice for applications such as mats, brushes, and composite material preparation.

Coir fiber waste was collected from a local vendor, which underwent a specific treatment process. Initially, the fibers were immersed in a caustic soda-water mixture for a duration of 4 hours to eliminate dust particles and extract the fibers. Subsequently, the fibers were subjected to a 5% NaOH solution treatment for 1 hour, followed by thorough rinsing with distilled water. The cleaned fibers were then dried naturally in sunlight for 2 hours and further dried in an oven at 60°C. The fibers were cut in a range of 10 mm to 15 mm in length and stored in an airtight bag.

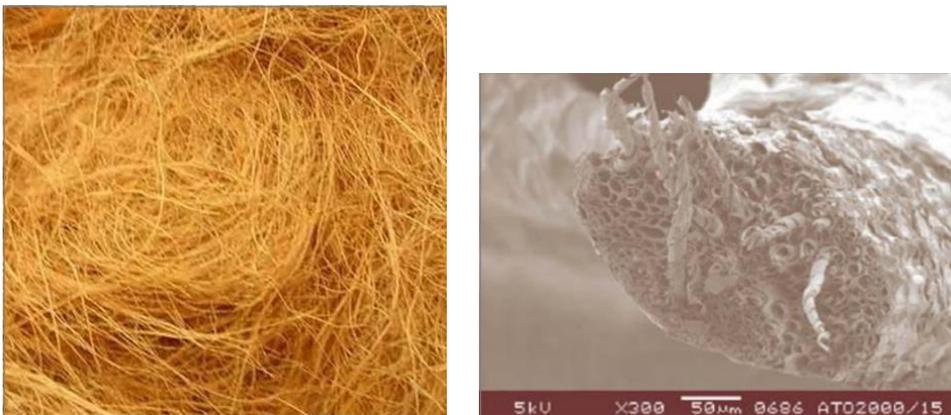


Figure 1: Coconut coir fiber and its closeup image.

2.2. Resin and Hardener

The epoxy resin employed in this process is Araldite LY 556, also known as Biphenyl-A Diglyceryl-Ether. It is combined with the hardener HY 951 in a ratio of 10:1, enhancing the interconnection between fibers and

the matrix. Additionally, Poly Foam Soft can be incorporated in a weight ratio of 2:1, yielding softer foam. Adjusting the isocyanate content allows for variations in foam firmness; increasing it results in firmer foam, while decreasing it yields softer foam. Users must conduct thorough testing of their chosen ratios before initiating full-scale production. Coir, derived from the agave of coconut palms, is esteemed for its robustness, elasticity, longevity, and dye-absorbing characteristics, making it highly sought-after for cordage applications. However, its specific stiffness may render composites less suitable for certain low-tech requirements. Epoxy resin plays a critical role in composite manufacturing because of its unique properties, especially when combined with coir fiber. Epoxies are thermoset plastics, and as a resin, epoxy enhances the properties of coir fiber by binding to composite materials. The natural ratio for epoxy resin mixture is 60:40 (fiber to resin).

2.3. Fabrication of Specimens

The specimens of 29.5 mm and 99.5 mm diameters were fabricated using a hot press technique. In this process, layers of fibers and matrix material were layered in a circular mold with 75% fiber and 25% starch. The mold was then heated to 180°C using a heater. Subsequently, a pressure of 50 tons was applied to the mold, which was maintained for a duration of 24 hours. As a result of this process, specimens with uniform structures were obtained, each having varying thicknesses of 7.5 mm, 6.8 mm, and 6 mm.

The developed specimen was examined using scanning electron microscopy, as shown in **Figure 2**. The image reveals good bonding between the fiber and matrix materials, with fibers arranged in a way that creates porosity at a few places — an essential feature for acoustic materials.

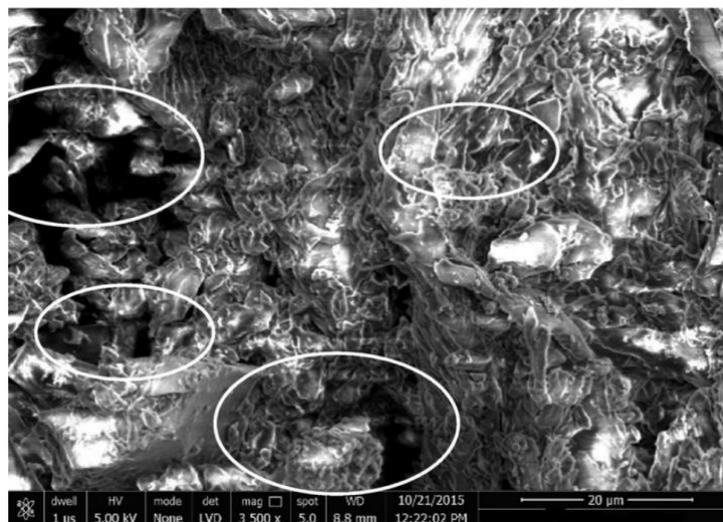


Figure 2: SEM image of developed coir fiber composite.

III. RESULTS AND DISCUSSION

3.1. Effect of Varying Thickness on Sound Absorption in Coir Fiber Composite

The analysis of Figure 3 indicates a notable impact of material thickness on the acoustic properties of the developed material.

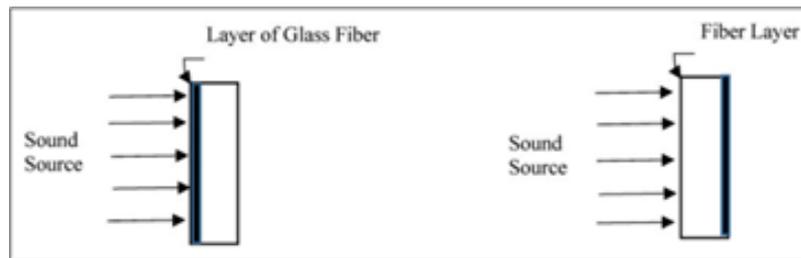


Figure 3: Placement of samples with respect to sound source. (a) Glass fiber layer toward the sound source (Arrangement 1). (b) Fiber layer (coir) toward the sound source (Arrangement 2).

In Figure 4(a), it is evident that with Arrangement 1, materials with greater thickness exhibit superior sound absorption coefficients. Lower thickness levels display considerable fluctuations, especially in the lower frequency range. Figure 4(b) corroborates these findings, showing that increased thickness leads to higher sound absorption coefficients, though with more pronounced fluctuations at lower frequencies. Notably, samples with a thickness of 7.5 mm demonstrate the highest and most consistent sound absorption performance. In comparison, samples with 6.8 mm thickness exhibit moderate sound absorption, while those with 6 mm thickness show lower absorption coefficients than their thicker counterparts.

In both arrangements — whether the glass fiber is oriented towards the sound source or the natural fiber is directed toward the sound source — it is evident that at medium and high frequencies, there are fewer fluctuations across all thickness levels.

However, it is noteworthy that in the first arrangement, where the glass fiber faces the sound source, the sound absorption performance is consistently lower across various thickness values compared to the second arrangement. Specifically, when the sound source is directed toward the natural fiber and the specimen has a thickness of 7.5 mm, the material exhibits the highest sound absorption coefficient observed.

In the first arrangement, the material exhibited the highest absorption coefficient at medium sound wave frequencies. However, as the frequency increased, the absorption coefficient decreased. In contrast, the second arrangement showed an increase in sound absorption coefficient with thicker materials. This difference can be attributed to the natural fiber's more porous structure compared to glass fiber. The natural fiber's abundant air cavities allow sound waves to easily pass through, dissipating energy as heat with increasing thickness. In the first arrangement, more sound waves reflect than are absorbed, leading to a lower coefficient of absorption. Meanwhile, the porous nature of the second arrangement enables more sound waves to be absorbed and transmitted through the material, resulting in a higher absorption coefficient.

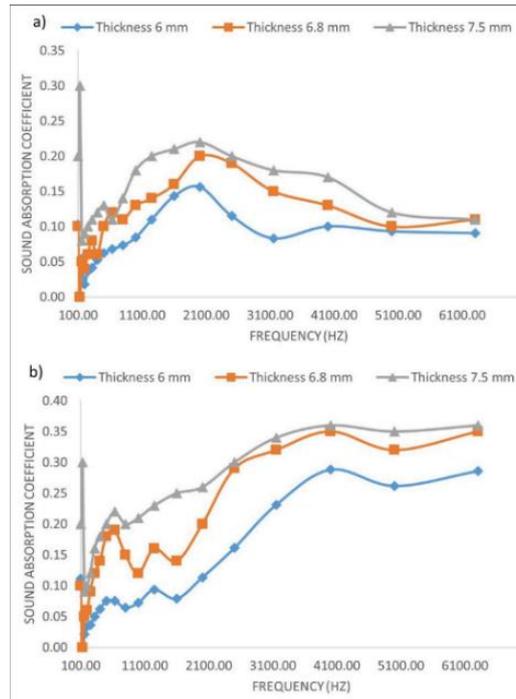


Figure 4: Sound absorption coefficient of samples having different thickness. (a) Arrangement 1. (b) Arrangement 2.

3.2. Effect of Arrangement on Sound Absorption Coefficient in Coir Fiber Composite

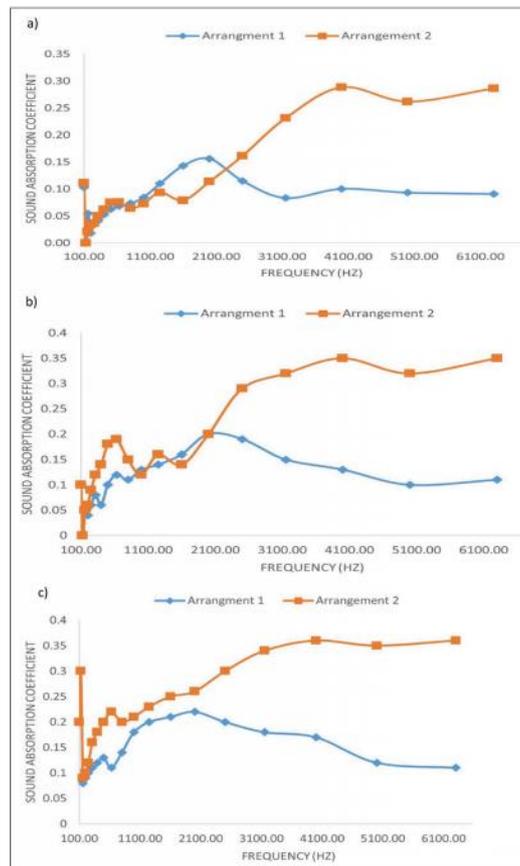


Figure 5: Sound absorption coefficient of different arrangements. (a) Thickness 6 mm, (b) 6.8 mm, and (c) 7.5 mm.

Two distinct arrangements were tested for sound absorption, with Arrangement 1 placing glass fiber toward the sound source and Arrangement 2 using natural fibers in the same position, as shown in Figure 5. An intriguing pattern emerged when considering different thicknesses. In Arrangements 1 and 2, samples with

thicknesses of 6 mm and 7.5 mm exhibited significant fluctuations at lower frequencies, stabilizing as the frequency increased. However, the 6.8 mm thick sample in Arrangement 1 showed a different absorption pattern. In Arrangement 2, the sound absorption coefficient increased with higher frequencies, whereas in Arrangement 1, it decreased in the higher frequency range, a trend observed across all thicknesses (6 mm, 6.8 mm, and 7.5 mm). Arrangement 2 consistently demonstrated more stable sound absorption compared to Arrangement 1. Notably, the difference in sound absorption was more noticeable at higher frequencies, with minimal disparities at lower and medium ranges.

3.3. Survey Analysis

The market is ready for a coir acoustic panel and values its eco-friendly nature. However, it is sceptical and cautious.

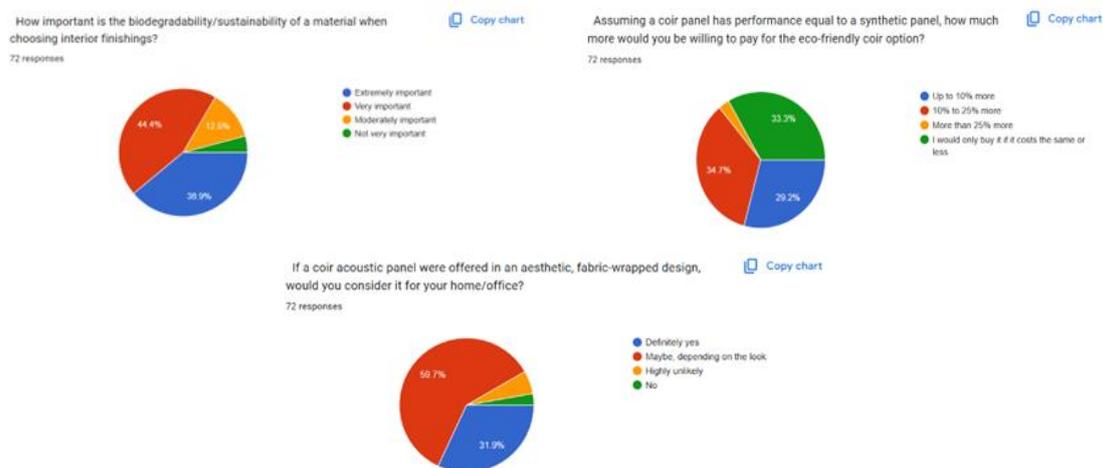


Figure 6: Survey on coconut coir as a soundproofing material.

Sustainability is Highly Important: The vast majority of respondents consider sustainability/biodegradability to be very important when selecting materials. "Very important" is the leading response at 44.4%, and "Extremely important" is the second largest at 38.9%. Combined, 83.3% of respondents consider sustainability to be Very or Extremely important. Only a small minority views sustainability with low importance: "Moderately important" accounts for 12.5%, and "Not very important" is the smallest segment (4.2%).

Significant Price Sensitivity: A large segment of the market (33.3%) is not willing to pay a premium for the eco-friendly option, stating they "would only buy it if it costs the same or less." Over 63% of respondents are willing to pay a moderate premium (up to 25% more) for the sustainable coir option. The 10% to 25% premium segment is the largest single group at 34.7%. The "up to 10% more" group is the second largest at 29.2%.

Recommended Strategy — Performance-First, Design-Second, Sustainability-Always: Product Foundation: Secure and promote certified fire resistance and anti-pest/fungal treatments. Primary Sale: Lead the marketing with certified Noise Reduction Efficiency and highlight Aesthetic Design (fabric-wrapped, clean lines). Competitive Edge: Use Sustainability and the Humidity Regulation feature to justify the premium price point (up to 25% more than synthetic alternatives).

IV. LITERATURE REVIEW

4.1. Literature Review Matrix

Author & Year	Purpose of the Study	Method Used	Key Findings	Limitations / Gaps
Nissar et al. (2025)	To provide a comprehensive, architecture-focused review that integrates material science, fabrication techniques, and real-world architectural applications of coir-based composites.	Comprehensive Review, integrating material science and fabrication techniques.	Coir's high lignin content guarantees stiffness, biological resistance, and dimensional stability. Advancements in fiber treatment improved fiber-matrix adhesion and durability. Coir boards offer lower density, effective thermal/acoustic insulation, and reduce embodied carbon.	Moisture sensitivity, inconsistent fiber quality, and production scaling are challenges. Further investigation needed for long-lasting, sustainable substitutes.
Krishnasamy et al. (2024)	To experimentally assess the sound absorption coefficients (SAC) and thermal insulating properties of coir/jute hybrid composite materials for use as functional materials.	Compression molding of six coir/jute blend proportions. Tested SAC using the Impedance Tube Method (ASTM E1050) and Thermal Conductivity using Lee's disk method (ASTM C177).	Sample S4 C/J (70% coir / 30% jute) exhibited exceptional SAC for high-frequency sound waves (above 2500 Hz), exceeding 0.83%. S5 C/J and S6 C/J showed an improvement in thermal conductivity compared to rigid polyurethane foam. Poor interfacial bonding led to fiber detachment from the resin surface in tensile tests.	Poor interfacial bonding (fiber detachment) was observed in visual analysis post-tensile testing.
Parikh et al. (2025)	To explore the acoustic properties of a bio-composite material derived from coconut coir fiber and potato starch, investigating the effects of material composition, thickness, and structural arrangement.	Fabrication via hot press technique (75% fiber / 25% starch). SAC measured using the Impedance Tube Method (ASTM E 1050-12). Hybridized with a single glass fiber layer for durability testing.	SAC demonstrates an increasing trend with thickness; 7.5 mm achieved the highest SAC (up to 0.55) in the high-frequency range. Placing the natural fiber layer facing the sound source significantly improved SAC compared to glass fiber facing the source. Natural coir fiber exhibited a greater SAC than the synthetic glass fiber.	Research could be extended to identify the effect of various fiber orientation, fiber weight fraction, and fiber length on SAC.

4.2. Research Gap Statement

While coir composites show excellent acoustic and thermal properties, fundamental knowledge gaps remain in optimizing fiber orientation, length, and content to ensure consistent, large-scale quality. Specifically, solutions are needed to overcome inconsistent fiber-matrix bonding observed during testing, which currently limits industrial scalability and material durability.

4.3. Summary

Natural fiber composites, particularly those reinforced with coconut coir, are highly promising sustainable materials for architecture, offering advantages in low cost, biodegradability, and excellent thermal/acoustic insulation. Research confirms that properties like sound absorption and durability are critically influenced by

material factors such as thickness and structural arrangement. For instance, hybrid coir/jute composites exhibit exceptional sound absorption coefficients ($>0.83\%$) at high frequencies when fiber composition is optimized.

V. HYPOTHESIS

5.1. Variables

Independent Variable: Coconut Coir

Dependent Variable: Soundproofing

5.2. Understanding the Relationship

The relationship between the two variables — coconut coir and soundproofing — is that the quantity of the coconut coir affects the quality of soundproofing.

5.3. Hypothesis Statements

Declarative Hypothesis: Coconut coir composite panels treated for durability and structural integrity will achieve a Noise Reduction Coefficient (NRC) value comparable to, or greater than, standard synthetic acoustic foam panels.

Null Hypothesis: The Noise Reduction Coefficient (NRC) value of coconut coir composite panels is significantly lower than that of standard synthetic acoustic foam panels.

Question Form: Does a coconut coir composite panel achieve a Noise Reduction Coefficient (NRC) that is statistically equivalent to or better than a standard synthetic acoustic foam panel?

5.4. Make it Testable

NRC value (Dependent Variable) can be precisely quantified using standard scientific procedures. The treatment and panel type (Independent Variable) are clearly defined (coir composite vs. synthetic foam). This directly addresses the research objective of Acoustic Performance Validation.

VI. CONCLUSION

The research successfully investigated coconut coir fiber as a sustainable, innovative, and decorative material for interior soundproofing and acoustic design, establishing coir composites as a promising, eco-friendly alternative to traditional commercial sound absorbers like glass or mineral fibers.

The study focused on brown coir fiber, fabricating specimens (75% fiber, 25% starch) using a hot press technique, and Scanning Electron Microscopy (SEM) confirmed the desired structural porosity and good bonding. Acoustic testing revealed a direct correlation between thickness and performance, with the 7.5 mm thick samples showing the highest and most consistent sound absorption.

Furthermore, when the Natural Fiber was oriented toward the sound source (Arrangement 2), the performance was consistently superior and more stable than Arrangement 1, particularly at higher frequencies, which is attributed to the coir fiber's highly porous structure dissipating sound energy as heat. Given the market's readiness but caution regarding coir acoustic panels, the recommended commercial strategy is Performance-First, Design-Second, Sustainability-Always, leveraging certified Noise Reduction Efficiency, Aesthetic Design, and features like Humidity Regulation to justify a premium price point.

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