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Development of Low Cost Noise Absorbing Sheet Using Waste Product

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Abstract: This study has been undertaken to develop low cost noise absorbing sheet using waste product. This research has investigated the acoustic behavior of composite materials developed from recycled wastes which are considered to be cost beneficial and also a green building initiative. The waste materials have shown better acoustical performance especially at mixed levels than the pure levels due to improvement in the porosity. The maize and textile fiber waste combinations show a better sound absorbing property than the newspaper and textile fiber wastes due to reduction in voids which reduces the porosity.

***IndexTerms* – Noise, waste product**

I. INTRODUCTION

In recent years, the issue of indoor sound pollution has garnered in- creasing attention due to its detrimental effects on human health and well-being. Excessive noise levels in indoor environments, originating from various sources such as construction activities, mechanical systems, and domestic appliances, can lead to a range of physical and psycho- logical health problems. As the world becomes more urbanized and densely populated, finding sustainable and effective solutions to com- bat indoor sound pollution is of utmost importance. This project aims to address the problem of indoor sound pollution by developing noise-absorbing sheets using biodegradable agro-waste materials. The utilize- ton of biodegradable waste offers a promising avenue for sustainable and eco-friendly alternatives to conventional noise insulation materials. By repurposing agro waste, such as agricultural residues or discarded plant fibers can reduce environmental impact, promote waste management practices, and create value-added products that contribute to a circular economy. The objectives of this project are twofold: To investigate the impact of indoor sound pollution on human health and to develop noise- absorbing sheets from biodegradable agro-waste materials. The outcome of this project is expected to have significant implications for both environmental sustainability and human health. By repurposing biodegradable agro waste into noise-absorbing sheets can contribute to waste reduction, promote eco-friendly practices, and alleviate the ad- verse effects of indoor sound pollution on individuals.

Furthermore, the development of cost-effective and sustainable solutions can pave the way for wider adoption and implementation in various indoor environments, such as residential buildings, offices, educational institutions, and health care facilities.

1.1 MATERIAL:

Material Preparation

Rice Husk and Straw

Rice husk and straw are common types of agro waste that have shown promising noise absorption properties. Here is an overview of their noise absorption characteristics:

Rice husk is the outer layer of rice grains that is separated during the milling process. It is a lightweight and abundant agricultural by product. Some key properties of rice husk that contribute to its noise absorption capability include:

Porous Structure: Rice husk has a highly porous structure with a large number of interconnected air pockets. These pores facilitate the absorption and dissipation of sound waves, thereby reducing the overall noise level.

Fibrous Composition: Rice husk contains fibrous materials that help trap and attenuate sound waves. The fibrous structure resists sound transmission, effectively absorbing and dissipating noise energy.

Low Density: The low density of rice husk contributes to its sound absorption properties by increasing the surface area available for sound wave interaction. This feature enhances its ability to atten- uate and scatter sound.

Straw:

Straw is the dry stalk residue left after grain crops (such as wheat, barley, or oats) are harvested. It is widely available and often considered as waste. Straw exhibits the following characteristics that make it suitable for noise absorption:

Fibrous Composition: Similar to rice husk, straw possesses a fibrous composition, enabling it to trap and dampen sound waves. The in terweaving structure of straw fibers offers effective sound absorption capabilities.

Variable Thickness: Straw stems have varying thicknesses along their length, creating an irregular surface. This irregularity helps to scatter and diffuse sound waves, reducing their intensity.

Low Density and Porosity: Straw's low density and high porosity contribute to its noise absorption properties. The empty spaces within the straw structure allow for the penetration and dissipation of sound waves.

It is important to note that while rice husk and straw exhibit inherent noise absorption characteristics, further processing and refinement may be required to optimize their effectiveness as noise-absorbing materials. Techniques such as densification, compaction, or combining them with other sound-absorbing materials may enhance their performance.

Wheat Husk and Straw

Wheat husk, similar to rice husk and straw, is an agricultural by product that exhibits noise absorption properties. While research specifically on the noise absorption characteristics of wheat husk is limited, it shares similarities with other plant-based agro waste materials. Here are some general aspects to consider regarding wheat husk's noise absorption properties

Porous Structure: Wheat husk typically possesses a porous structure with interconnected voids. This porous nature allows sound waves to penetrate and be trapped within the material, leading to sound attenuation.

Fibrous Composition: Wheat husk, like other plant-based agro waste, contains fibrous components. These fibers can absorb sound energy and dissipate it as heat through their inherent damping properties.

Irregular Surface: The irregular surface of wheat husk, characterized by uneven textures and variations in thickness, aids in sound diffusion and scattering. This feature helps to reduce sound intensity and prevent the reflection of sound waves.

Density and Thickness: The density and thickness of wheat husk can influence its noise absorption properties. Generally, lower-density materials with increased thickness offer better noise absorption capabilities due to increased surface area and greater air space for sound wave inter- action.

Coconut Fibre

Coconut fiber, also known as coir, is a natural fiber extracted from the husk of coconuts. It has several applications, including being used as a sound-absorbing material. Here are some of the sound-absorbing prop- erties of coconut fiber:

Porous Structure: Coconut fiber has a highly porous structure due to its fibrous nature. This porosity allows it to effectively trap and absorb sound waves. When sound waves enter the fiber, they travel through the gaps between the fibers and encounter multiple surfaces, which lead to sound wave attenuation.

Air Gaps: The fibrous nature of coconut fiber creates air gaps within the material. These air gaps contribute to sound absorption by providing spaces where sound waves can enter and dissipate. The presence of these gaps helps to break up sound waves and reduce their intensity.

High Surface Area: Coconut fiber has a high surface area, which enhances its sound absorbing properties. The increased surface area allows for greater interaction between the sound waves and the fiber material, leading to improved absorption.

Fibrous Structure: The fibers in coconut fiber have irregular shapes and sizes, which scatter and diffuse sound waves. This scattering effect helps to prevent sound from reflecting directly back into the environment, reducing echo and reverberation.

1.2 OBJECTIVE OF PROPORSED WORK

1. To finalize composition of acoustic sheets and provide with real world solutions.
2. To manufacture low cost sound absorbing system.
3. To test different combinations of acoustic sheets by creation of test kit.

1.3 RESEARCH METHODOLOGY OF STUDY

Methodology involves collection of waste material and manufacturing a sheet. A miniature room model is developed to conduct noise absorption test. Methodology of this study is given in the following flow chart shown in figure.

1.3.1MANUFACTURING OF ACOUSTIC SHEETS

Method 1: Manufacturing sheets using Sugar Syrup

Agro waste sheets can be made using sugar syrup as a binder or adhesive. The process involves combining agro waste fibers with a solution of sugar syrup to create a mixture that can be formed into sheets or mats. Here's overview of the process:

Step 1: Agro waste selection: Choose suitable agro waste materials such as rice straw, wheat straw and coconut fiber. These materials should be chopped or shredded into smaller pieces to enhance their suitability for sheet formation.

Step 2: Sugar syrup preparation: Prepare a sugar syrup solution by dissolving sugar in water. The ratio of sugar to water can vary depending on the de- sired consistency and binding strength. Addition of vinegar and flavour powder is must step. Heat the mixture until the sugar is completely dissolved, and then allows it to cool as shown in fig.1

Step 3: Mixing fibers and sugar syrup: Take the agro waste fibers and mix them with the prepared sugar syrup solution. The mixture should be thoroughly stirred to ensure that the fibers are evenly coated with the syrup.

Step 4:Sheet formation: Once the fibers are well-coated, the mixture is ready for sheet formation. Grease is applied on the mould for the easy removal of sheet. Spread the mixture evenly on a flat surface in the mould and press it using hands or a roller to form a uniform sheet.

Figure 1: Spreading the mixture in the mould

This mould is then allowed to be sundried for 24 hours. Gypsum powder is spread on all sides of sheet after 24 hours for making the surface even, and then sheets are allowed to dry for next 12 hours.

Method 2: Hot pressing the fine agro-waste in Hot Press Ma- chine.

The process involves applying heat and pressure to the agro waste, which causes it to bind together and form a solid sheet. Here are the general steps involved in hot pressing agro waste:

Step 1: Preparation: Collect the agro waste material, such as straw, husks, or stalks, and prepare it for processing. This may involve cleaning, drying, or grinding the waste to achieve a consistent size and remove any impurities.

Step 2: Mixing: If desired, mix the agro waste material with a binder or adhesive to improve the strength and cohesiveness of the resulting sheets. Common binders include resins, starch, or natural adhesives.

Step 3: Loading the hot press machine: Place the prepared agro waste or the mixture of waste and binder into the hot press machine. Ensure that the material is evenly distributed and covers the desired surface area.

Step 4: Applying heat: Close the hot press machine and activate the heating elements. The temperature and duration of the heating process is depend on the type of agro waste and binder used. Typically, temperatures range from 100 to 200 degrees Celsius (212 to 392 degrees Fahrenheit).

Step 5: Applying pressure: Once the desired temperature is reached, the hot press machine exerts pressure on the agro waste material. The pressure helps to compress the fibers and promote bonding. The pressure and duration of this step also vary depending on the specific requirements and material characteristics.

Step 6: Cooling and releasing: After the pressing and bonding phase, the hot press machine gradually cools down. This cooling process allows the sheet to solidify and maintain its shape. Once cooled, the press is opened, and the newly formed sheet can be removed as shown in figure 2.

Figure 2: Sheet

Step 7: Finishing: Depending on the intended application, it may need to further process the agro waste sheets. This could involve trimming, sanding, or coating them to achieve the desired final product.

Table 1.3.1.1: Composition of agro-waste

SR NO.	Specimen	Method	Rice Husk	Wheat Husk	Coconut Fiber	Sugar Syrup
1	Sheet 1	Method 1	3	1	1	2
2	Sheet 2	Method 1	2	1	0.5	1
3	Sheet 3	Method 2	3	2	0.5	1
4	Sheet 4	Method 2	2	2	0.5	1

1.3.2 Preparation of Mini Testing Room

Preparing a mini sound testing room involves creating an environment that minimizes external noise and provides controlled conditions for con- ducting sound tests as shown in figure 3.

Figure 3. Preparing the Room

Materials and Tools:

- Plywood sheets (choose an appropriate thickness based on requirement)
- Lumber (2x4 or 2x6 boards).
- Nails or screws.
- Circular saw or table saw.
- Hammer or drill Level.
- Measuring tape.
- Safety goggles.
- Work gloves.
- Paint or finishing materials.

Dimension of Room: The room’s dimension is 1.5ft (Length) * 1 ft (Width) * 1 ft (Height).

1.3.3 Making sound Sensor and Embodying it in the Testing Room

Microphone Module: A small microphone module that can capture sound waves and convert them into electrical signals.

Analog-to-Digital Converter (ADC) Module: This module is necessary if microcontroller does not have an integrated ADC. It converts the analog signals from the microphone into digital values that can be processed by the microcontroller.

Jumper Wires: These wires are used to connect the various components together. Breadboard or PCB: A breadboard can be used for prototyping, while a printed circuit board (PCB) is a more permanent solution.

Microcontroller: A microcontroller board,such as an Ar- duino, ESP 8266, ESP32, to process the sensor data and perform further actions based on the sound input.

USB Cable: A USB cable is necessary to connect the microcontroller to computer for programming and power supply.

Computer: A computer with an integrated development environment (IDE) installed, such as Arduino IDE or the ESP-IDF, to program the microcontroller.

Soldering Iron and Solder (optional): soldering the components onto a PCB, a soldering iron and solder to make the connections.

Multi-meter: A multi-meter is useful for testing and troubleshooting the connections and voltages.

Wire Cutter and Stripper: These tools is used to cut and strip the jumper wires to the desired length.

II. LITERATURE REVIEW

Balan A.V. amp & Shivasankaran N. investigated into the acoustic properties of composite materials made from recycled garbage, which are thought to be cheaper to produce economical and a green building project as well. Because of an increase in porosity, the waste materials have shown better acoustical performance, especially at mixed levels compared to pure levels. [1]

K. Shankar (et al. 2022) Compared to another nonwoven fabric, the needle punched nonwoven cloth has a higher air permeability and thermal conductivity. This study found that the maximum sound absorption coefficient in the reverberation time near was 0.923. Among other things, the nonwoven fabric produced in this study can be used as a sound-absorbing material in commercial spaces including auditoriums, malls, and theaters. [2]

S. Mahzan(et al. 2009) has conducted comparison between virgin PU and the optimum percentage rice husk (25%) indicated that value of mixture is higher than virgin PU at low frequency whereas for high frequency the virgin PU is higher. [3]

K. Nagasahadeva Reddy (et al. 2020) proved that green material such as coconut fiber really suitable to replaced synthetic material by do some modifications on material and design toward green technology. [4]

III. TESTING

When working with acoustic sheets or materials, performing tests can help evaluate their acoustic properties and performance. These tests provide valuable information to assess the effectiveness of the material in controlling sound transmission, absorption, reflection, and other acoustic characteristics. Here are some tests performed on acoustic sheets.

3.1ACOUSTIC SHEETS AT DIFFERENT TEMPERATURES

When conducting sound absorption tests on materials, it’s important to consider the effects of temperature, as temperature can impact the acoustic properties of the material. Here are some different temperature tests that are performed on sound-absorbing materials:

Ambient Temperature Test: This test involves measuring the sound absorption coefficients of the material at the standard ambient temperature, typically around 27-35 degrees Celsius. It provides a baseline measurement of the material’s acoustic performance under normal temperature conditions.

High-Temperature Test: In this test, the sound absorption coefficients of the material are measured at elevated temperatures. The material is exposed to higher temperatures, such as 50-60 degrees Celsius, and the sound absorption performance is assessed. This test helps deter- mine if the material’s acoustic properties are affected by temperature increases.

Low-Temperature Test: The low-temperature test assesses the sound absorption coefficients of the material at colder temperatures. The material is subjected to lower temperatures, such as 10-20 degrees Celsius, and its acoustic performance is evaluated. This test is particularly relevant for applications in cold environments or where temperature variations may occur.

Table 3.1.Properties of Sheet at different temperature

SR NO.	Temperature (Degree Celcius)	Specimen	Remark
1	10-20	Sheet 1	Sugar Syrup made sheet brittle
		Sheet 2	Sugar Syrup made sheet brittle
		Sheet 3	No Change
		Sheet 4	No Change
2	25-35	Sheet 1	No Change
		Sheet 2	No Change
		Sheet 3	No Change
		Sheet 4	No Change
3	100-120	Sheet 1	Sheet turned brownish in colour
		Sheet 2	Sheet turned dark brownish in colour
		Sheet 3	Little to no brown colour is seen
		Sheet 4	Little to no brown colour is seen

3.2WATER ABSORPTION TEST

When evaluating the water absorption properties of acoustic sheets, a water absorption test can provide valuable information about the material’s performance in wet conditions. Here’s an overview of the water absorption test for acoustic sheets:

Sample Preparation: Cut representative samples of the acoustic sheet to be tested. The samples should be of sufficient size to provide meaningful results. Typically, square or rectangular samples are used.

Initial Weight Measurement: Accurately weigh each sample before the water absorption test. Record the initial weight of each sample.

Immersion: Completely submerge the samples in water for a specified duration. The duration may vary depending on the specific test requirements or relevant standards. Common durations include 24 hours or longer. Removal and Drainage: After the immersion period, remove the samples from the water and allow them to drain. Ensure that excess water is removed by gently pressing or squeezing the samples without causing damage or deformation.

Final Weight Measurement: After drainage, weigh each sample again to determine the final weight. The difference between the initial and final weights represents the amount of water absorbed by the acoustic sheet. Calculation and Analysis: Calculate the water absorption percentage using the following formula: Water Absorption (%) = [(Final Weight - Initial Weight) / Initial Weight] * 100. Analyse and compare the results obtained from different samples or materials. Consider factors such as the rate of water absorption, overall water absorption percentage, and any visual changes or damage to the samples.

3.2.1 Results & Discussion

Initial weight of the acoustic board (Sheet 1) = 39 grams
Initial weight of the acoustic board (Sheet 2) = 42 grams
Initial weight of the acoustic board (Sheet 2) = 70 grams
Initial weight of the acoustic board (Sheet 2) = 76 grams
Final weight of the acoustic board (Sheet 1) = 65 grams
Final weight of the acoustic board (Sheet 2) = 70 grams
Final weight of the acoustic board (Sheet 3) = 80 grams
Final weight of the acoustic board (Sheet 4) = 82 grams

The amount of water absorbed by the acoustic board = 100 * (w2- w1)/w2
Water absorption in percentage (Sheet 1) = 40.2%
Water absorption in percentage (Sheet 2) = 44%
Water absorption in percentage (Sheet 3) = 12.5%
Water absorption in percentage (Sheet 4) = 7.3%

3.3 Sound absorption test

For sound absorption test first take the testing room and place before different specimens inside the room where sound of a particular 100 dB is produced.

Table 3.3 Sound Absorption Test

Sr. No	Specimen	Sound inside(dB)	Soundout-side.(dB)	Efficiency	Remark (Efficiency)
1	Sheet 1	102.103	88.89	13 %	Moderate
2	Sheet 2	98.106	87.94	11 %	Low
3	Sheet 3	107.88	87.72	18 %	Moderate
4	Sheet 4	97.108	75.84	22 %	High

IV. Conclusion

By using an acoustic sheet, we can reduce the sound which is produced unnecessarily, especially in indoor conditions. But our aim is to reduce sound with less economy. By using agro waste as an acoustic material we experimented we concluded that this agro material is a good sound reducer and is produced with less economy. This project is a solution to one of the social activities which is sound pollution. People belonging to poor backgrounds can't adopt high-cost acoustic panels.

Using agricultural waste for sound absorption can provide farmers with additional revenue while also contributing to the reduction of pollution caused by burning such waste.

Agricultural waste is often burned, leading to air pollution and contributing to greenhouse gas emissions. By repurposing this waste into sound-absorbing materials, farmers can help mitigate pollution. This contributes to a cleaner environment and promotes sustainable practices. Utilizing agricultural waste for sound absorption provides an alternative solution for waste management. Instead of discarding or burning the waste, farmers can collect and process it into valuable products. This reduces the environmental impact associated with waste disposal and contributes to the circular economy by giving the waste a new purpose.

IV. Acknowledgment

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