Analysis of the Effectiveness Value of the Coconut Fiber (Cocos nucifera L) Absorption Coefficient as a Sound Dampener

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ABSTRACT

In this modern era, noise has become an increasingly common and significant problem in everyday life, thus requiring the use of sound absorbers to address this noise issue. This research created a sound absorber using coconut husk waste through the impedance tube method. Sound absorbers can be made by utilizing readily available waste materials, such as coconut husk waste. The effectiveness value of the coconut fiber absorption coefficient was tested using the impedance tube. The research method employed was the impedance tube method, with variations ranging from level 1 to level 5 and frequencies of 200 Hz, 400 Hz, 600 Hz, and 800 Hz. The impedance tube lengths used in this study were 50 cm and 100 cm. The highest absorption result at a tube length of 50 cm was found at level 1 with a frequency of 200 Hz. At a tube length of 100 cm, the highest absorption value was observed at level 2 with a frequency of 600 Hz. Based on this research, it was concluded that coconut husk can minimize noise and serve as an effective sound absorber.

Keywords: *Absorption Coefficient, Coconut Coir*

I. INTRODUCTION

Industrial activities, trade, power generation equipment, transportation equipment, and household activities are all examples of noise [1]. Information, communication, production, transportation, and entertainment facilities are developing so rapidly that most of them produce noise as a result of the rapid development of technology. The noise itself has become a problem that needs to be handled seriously. To anticipate this, various types of sound absorbers have been developed [2]. Silencers are a commonly used solution to overcome the effects of noise [3]. Technology for developing noise dampening has been widely carried out from a technical perspective as well as types of materials originating from nature and waste, including the use of sawdust waste as a sound-dampening material [4].

Coconut fiber is a solid waste from the coconut oil industry, a food sourced from coconuts that is widely consumed by people in Indonesia. Coconut fiber is the highest percentage of coconut processing waste [5]. The classification of fiber is based on its origin, namely coconut fiber itself is a type of natural fiber that comes from the coconut plant. If coconut fiber is broken down, it will produce coir fiber (coco fiber) and coir powder (coco coir) [6]. Therefore, we are interested in investigating coconut fiber in order to learn more about its sound-dampening properties and to take advantage of its abundant presence in the surrounding environment. In this case, we are interested in analyzing the effectiveness value of the absorption coefficient of coconut fiber, the location of which is taken in Samarinda City, precisely at Pasar Kemuning, Jalan Loa Bakung as a place to sell coconuts. The existing types of sound-dampening materials are porous materials, resonators, and panels [7]. Of the three types of materials, porous materials are often used. Especially to reduce noise in narrow spaces such as housing and offices. This is because porous materials are relatively cheaper and lighter than other types of dampers [7]. For many years, glasswool and rockwool have been the standard materials for soundproofing. However, due

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to their high cost, alternative materials are increasingly being developed. These substitutes include various types of cork and fiber-composed materials [8].

Sound absorption is the change of energy into another form, usually heat that has passed through a material surface. Apart from that, it also takes the form of sound that passes through the surface of the material, so that the sound that has passed through the material will change to become smaller. The principle of sound absorption occurs when a substance or material used loses energy when a sound wave hits and is reflected from a substance or material so that the sound is transmitted, absorbed, and reflected. However, the amount of sound absorbed, reflected, and transmitted depends on the type of material used [9].

II. RESEARCH METHODS

The research was conducted at the Physics Laboratory, Faculty of Teacher Training and Education, Mulawarman University for two weeks. The flow diagram of the activities can be seen in Figure 1.

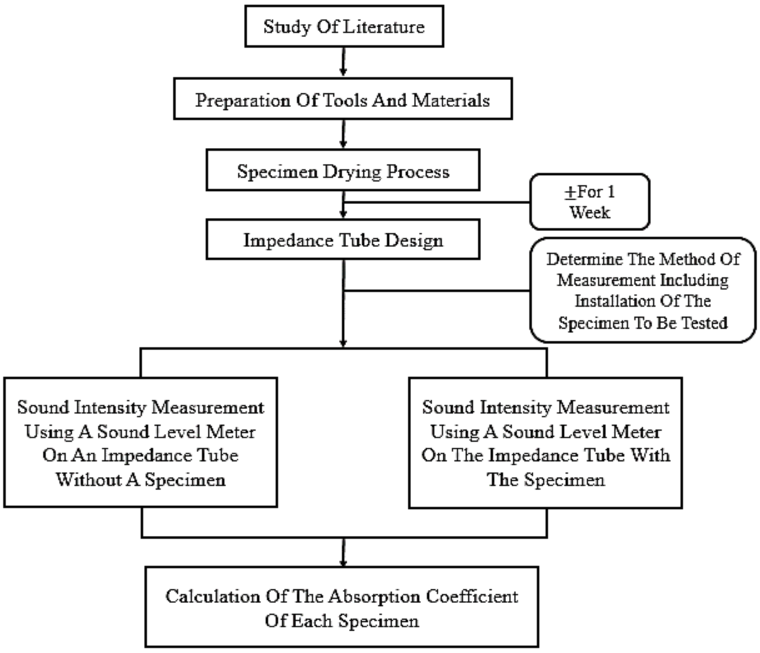

Figure 1. Research Flow Diagram

In Figure 1, the research began with a literature study, then what was done was preparing the tools and materials needed, such as coconut fiber, which were then dried with the aim of increasing the effectiveness and quality of these materials. After the coconut fiber was dry, then pounded it and stuck it together. Therefore, when the coconut fiber is installed on the tube, it will function optimally as a sound wave destroyer.

After drying the material, the next step was to determine the impedance tube design. The tools needed to design an impedance tube were plywood boards 50 cm and 100 cm long, masking tape and double-sided tape, loudspeakers and an audio generator as well as a sound intensity measuring tool, namely a sound level meter. Figure 2 is a design of the impedance tube that will be used to test the absorption coefficient of materials. Impedance tubes were designed to be able to measure the intensity of sound in the tube produced by an audio generator using a sound level meter.

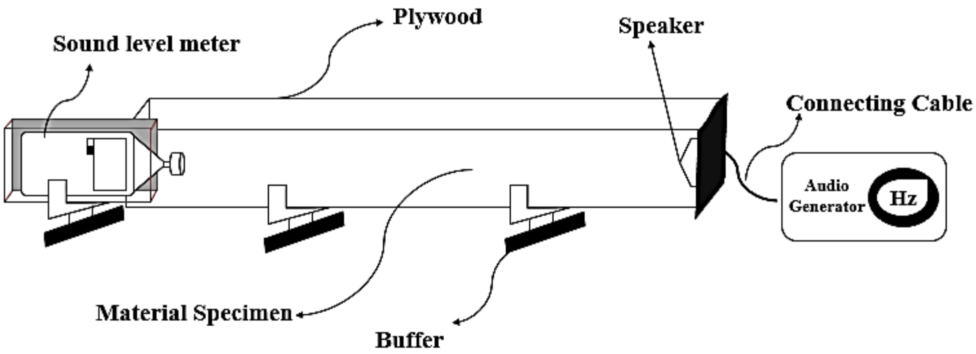

Figure 2. Impedance Tube Design

Figure 3 shows the results of the tool design. After the device was assembled, the sound intensity was measured on the impedance tube. Measurements were carried out without a layer of material in the impedance tube. The sound intensity value obtained was denoted by I_0. After measuring the sound intensity on the impedance tube without material, the dried material was then placed to coat the inside of the tube. So that installation can be done easily, the impedance tube was split crosswise. The process of installing the material into the tube can be seen in Figure 4.

Figure 3. Impedance Tube Design Results

Figure 4 is the installation of coconut fiber on a plywood board. After the inner side of the plywood board was covered with material, the plywood board was put back together using black duct tape and then the sound intensity was measured. The sound intensity data obtained was denoted by I. After obtaining the sound intensity value of the impedance tube without materials (I_0) and the sound intensity of each material (I). Next, the absorption coefficient (α) value was calculated using Eq. (1) [10].

$$\alpha = -\frac{1}{x}\ln\frac{I}{I_0}$$

Figure 4. Installing coconut fiber on a plywood board

III. RESULTS AND DISCUSSION

The analysis of the results of measuring the absorption coefficient in an impedance tube with a diameter of 50 cm can be seen in Table 1. Table 1 shows the data obtained from the results of sound intensity measurements at a diameter of 50 cm. Each frequency level of sound intensity in the audio generator varied five times from level 1 to level 5. From the data on the table, it can be seen that there was a decrease in sound intensity from the impedance tube, which was previously not covered with coconut fiber material, after which coconut fiber material was installed. The highest average decrease in sound intensity occurred at a frequency of 600 Hz, with a reduction in sound intensity of 14.94 dB from the original intensity. From the sound intensity data, the absorption coefficient value of coconut fiber can then be calculated.

Table 1. Results of measuring sound intensity values in empty impedance tubes (I_0) and sound intensity in impedance tubes coated with coconut fiber material (I) with a tube diameter of 50 cm

Frequency (Hz)	Levels	Intensity (dB)		Decreased Sound Intensity (dB)
		I_o	I	
200	1	127,6	94,0	33,6
	2	131,5	99,2	32,3
	3	132,3	111,7	20,6
	4	132,7	127,5	5,2
	5	133,0	128,1	4,9
Average Decrease In Sound Intensity (dB)				**19,2**
400	1	109,6	104,2	5,4
	2	113,5	107,9	5,6
	3	114,3	112,0	2,3
	4	114,9	113,6	1,3
	5	116,8	114,0	2,8
Average Decrease In Sound Intensity (dB)				**3,48**
600	1	116,6	101,1	15,5
	2	117,9	102,8	15,1
	3	118,7	103,4	15,3
	4	119,6	104,5	15,1
	5	119,9	106,2	13,7
Average Decrease In Sound Intensity (dB)				**14,94**
800	1	112,8	110,3	2,5
	2	116,6	111,1	5,5
	3	118,9	111,9	7,0
	4	120,9	112,0	8,9
	5	123,7	112,2	11,5
Average Decrease In Sound Intensity (dB)				**7,08**

The results of collecting initial intensity data and material intensity in a tube with a diameter of 50 cm can be seen in Figure 5. Figure 5 shows a graph of the absorption coefficient of coconut fiber, which has a different maximum absorption at each frequency. It has the highest coefficient at level 1 at 200 Hz. When a frequency is 400 Hz, the coefficient is the highest at level 1; when a frequency is 600 Hz, the coefficient is the highest at level 1; and when it is 800 Hz, the coefficient is the highest at level 5. As a result, the coefficient and effectiveness are largest at 200 Hz.

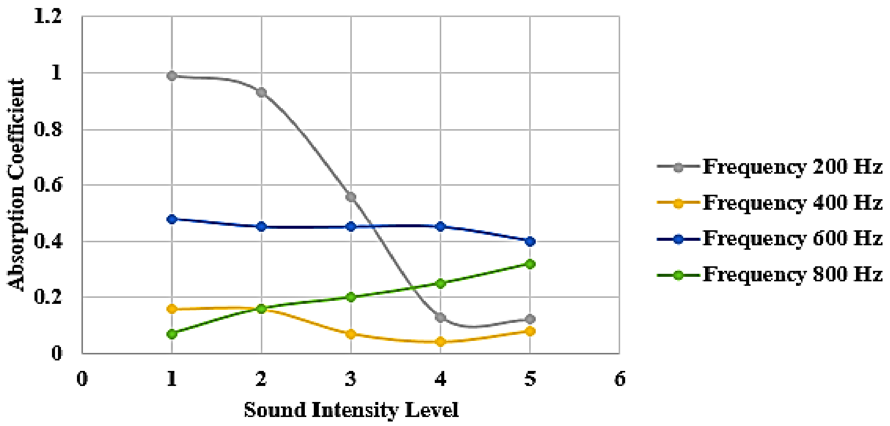

Figure 5. Comparison graph of the absorption coefficient of coconut fiber at five different sound intensity levels at each frequency

Table 2. Results of measuring sound intensity values in empty impedance tubes (I_0) and sound intensity in impedance tubes coated with coconut fiber material (I) with a tube diameter of 100 cm

Frequency (Hz)	**Levels**	**Intensity (dB)**		**Decreased Sound Intensity (dB)**
		I_o	I	
200	1	71,6	67,9	3,7
	2	72,1	69,2	2,9
	3	81,8	79,0	2,8
	4	83,9	80,4	3,5
	5	98,2	87,4	10,8
Average Decrease In Sound Intensity (dB)				**4,74**
400	1	88,5	83,3	5,2
	2	90,7	86,6	4,1
	3	99,1	91,9	7,2
	4	98,9	92,3	6,6
	5	99,4	98,6	0,8
Average Decrease In Sound Intensity (dB)				**4,78**
600	1	101,8	90,6	11,2
	2	102,8	91,1	11,7
	3	103,4	94,1	9,3
	4	104,6	96,6	8,0
	5	105,5	99,7	5,8
Average Decrease In Sound Intensity (dB)				**9,2**
800	1	118,6	98,1	20,5
	2	120,7	115,2	5,5
	3	122,2	116,8	5,4
	4	123,7	118,1	5,6
	5	125,4	120,0	5,4
Average Decrease In Sound Intensity (dB)				**8,48**

The analysis of the results of measuring the absorption coefficient in an impedance tube with a diameter of 100 cm can be seen in Table 2. Table 2 shows the data obtained from the results of sound intensity measurements at a diameter of 100 cm. Each frequency level of sound intensity in the audio generator varied five times from level 1 to level 5. From the data above, there was a decrease in sound intensity from the impedance tube, which was previously not covered with coconut fiber material, after which coconut fiber material was installed. The highest average decrease in sound intensity occurred at a frequency of 600 Hz, with a reduction in sound intensity of 9.2 dB from the original intensity.

From the sound intensity data, the absorption coefficient value of coconut fiber can then be calculated. The results of collecting initial intensity data and material intensity in a tube with a diameter of 100 cm can be seen in Figure 6. Figure 6 shows a graph of the absorption coefficient of coconut fiber which has a different maximum absorption at each frequency. At a frequency of 200 Hz, it has the largest coefficient at level 5, at a frequency of 400 Hz it has the largest coefficient at level 3, then at a frequency of 600 Hz, it has the largest coefficient at level 2, while at a frequency of 800 Hz, it has the highest coefficient at level 5. As a result, the coefficient and effectiveness are largest at a frequency of 600 Hz. Sound intensity level is a quantitative measure used to denote the strength or amplitude of sound. Expressed in decibels (dB), it provides an indication of the loudness or softness of the sound [11].

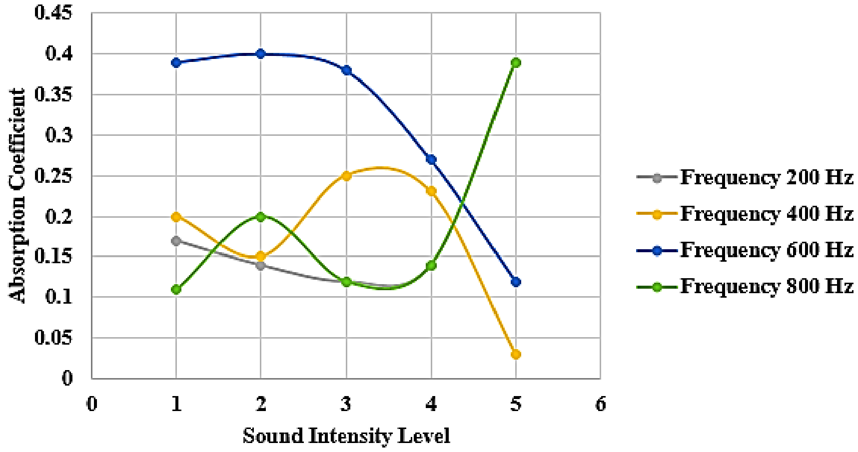

Figure 6. Comparison graph of the absorption coefficient of coconut fiber at five different sound intensity levels at each frequency

IV. CONCLUSION

In conclusion, our research on the effectiveness of coconut fiber (Cocos nucifera L) as a sound absorber, utilizing impedance tube analysis, has revealed promising findings. The absorption coefficient of coconut fiber demonstrates significant potential, which is particularly evident at specific frequencies and tube lengths. Notably, the highest absorption coefficients were observed at a tube length of 50 cm for the first-level frequency of 200 Hz and at a tube length of 100 cm for the second-level frequency of 600 Hz.

These results underscore the suitability of coconut fiber as a sound absorber, as it effectively attenuates sound waves across various frequencies. The ability of coconut fiber to minimize sound suggests its practical utility in soundproofing applications. This research highlights the promising prospects of utilizing natural materials like coconut fiber for acoustic insulation purposes, presenting an eco-friendly and effective solution for noise reduction in diverse settings.

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