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Utilization of coconut fiber and corn cob waste as noise reducers

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Abstract

Noise is a very disturbing problem in residential, office, educational, industrial and other environments. Noise can be reduced by using materials that can dampen and absorb sound. The sound dampening materials that are widely used by the public generally use glasswool and rockwool, but they are expensive. The more expensive the price of goods including sound absorbers, the more alternatives are needed by utilizing materials derived from nature which are easy to obtain and cheaper, besides that by utilizing existing natural fibers it can also reduce waste in the surrounding community. One example of utilizing waste from natural fibers is making composites using coconut fiber and corn cobs. Composite materials made from coconut coir fiber and corn cob are alternative sound absorbing materials that are environmentally friendly, easily available and inexpensive. The aim of the research was to obtain an optimum composition ratio to produce composites as environmentally friendly sound absorbing materials, to determine the value of the sound absorption coefficient (α) from the manufacture of coco fiber and corn cob composites as noise dampening materials. From the research results it can be concluded that the sound dampening ability results show varying values for each test specimen. The highest incoming sound/energy is 94.4 dB at a frequency of 500 Hz while the lowest incoming sound/energy is 44.14 dB at a frequency of 125 Hz. Meanwhile, the highest sound/absorbed energy (mean value) was 37.7 dB at a frequency of 750 Hz in sample C, while the lowest sound/absorbed energy was -6.16 dB at a frequency of 4000 Hz in sample A.

***Keywords**: composites, noise, sound absorbing materials*

1. Introduction

Environmental problems have become quite complex and dilemmatic. This encourages concern for the environment and energy to become very important, one way of increasing this concern can be realized by using materials derived from waste. The use of waste as material is based on several things, including increasing awareness of the environment, protecting natural resources, reducing carbon dioxide (CO2) emissions and recycling materials.

The success of development and economic growth carried out by utilizing natural resources leaves many negative impacts on the environment. If the environment is damaged, resources for development will become increasingly depleted and scarce. In this way, environmental damage will not only threaten the sustainability of development but also threaten human existence, for example through air pollution and solid waste.

Air pollution includes noise. Noise is unwanted sound from various sources that disturbs or endangers health (1). The noise threshold limit is based on the Republic of Indonesia Minister of Health regulation no. 1405 of 2002 is 85 dB (2), but the noise felt by urban communities is far from the permitted threshold (3).

Composite materials can be used as sound or noise absorbers (4). To get good soundproofing quality, the material must have fibers that can block incoming sound, even natural fiber is an environmentally friendly material and can be recycled (5). Meanwhile, noise can be reduced using materials that can dampen and absorb sound (6). Sound-absorbing materials have an important role in a room to reduce noise. To reduce noise in a room, acoustic panels are usually installed on the dividing walls and ceiling. The more expensive the price of goods, including sound absorbers, requires other alternatives by using materials that come from nature which are easily available and cheaper, apart from that, using existing natural fibers can also reduce waste in the surrounding community. One example of using natural fibers is making composites using coconut fiber and corn cobs. Not only does it have the ability to reduce sound, but several studies also discuss the strength of the material. The treatment of soaking natural fibers in NaOH has been studied to determine the strength of the material (7). The results obtained were that the NaOH soaking treatment produced greater strength than without treatment.

Based on this background, in this research the author tries to use materials derived from coconut fiber waste from buying and selling coconuts in traditional markets and corn cobs from agricultural products and epoxy resin as a matrix as a composite material for noise dampening. The aim of this research is to determine the optimum composition ratio to produce a composite as a sound dampening material, determine the value of the sound absorption coefficient (α) of the coconut fiber and corn cob fiber composite and determine whether there is a difference in the damping ability of each sample with frequency. different.

2. Methods

The manufacture of composites made from coconut fiber and corn cobs as noise dampeners was carried out at the Industrial Engineering Laboratory, Faculty of Science and Engineering, Bojonegoro University.

Coconut fiber is used as a basic material in making composites. This material was obtained from traditional markets in Bojonegoro Regency. Corn cobs are used as a basic ingredient in making composites. This material is obtained from rice fields or houses of corn farmers in Bojonegoro Regency. Epoxy resin, used as a matrix in composites. NaOH (Sodium Hydroxide) is used in the fiber soaking process which functions to clean the fiber from lignin, hemicellulose and other impurities. The pipe used has 4 inches diameter or approximately 10 cm. Vernier callipers are used to measure composite specimens. Digital scales are used to weigh the mass of coconut fiber and corn cobs. Scissors for cutting coconut fiber. The basin is used as a place to mix materials that will be formed into test specimens. Impedance tube to determine the sound absorption coefficient of the composite. Sound Level Meter is used to measure noise intensity levels.

The research stages to be carried out are described as follows:

1. Literature Study
   The initial stage of this research is literary study, literary study is used as a theoretical basis in solving problems scientifically. In this stage the writer looks for connections that relate to the research topic.
2. Preparation of tools and materials
   The second stage in this research is the preparation of the tools and materials used to make composite materials. The tools and materials that must be prepared are as written previously.
3. Making Specimens
   Composite is a material combined from two or more different materials. In making this composite, the basic ingredients are coconut fiber fiber and corn cobs. The next stage begins with cleaning the fibers that will be used as composite filler, then soaking the fibers in NaOH for 4 hours. After the fiber has finished soaking, the fiber is drained by filtering it using a sieve and sun-dried again until the fiber is completely dry. After drying, the next step is to make a composite with the ratio of matrix and filler used, which can be seen in table 1. Comparison of Matrix and Filler.

Table. 1. Comparison of Matrix and Filler

Comarison Filler: Matrix	Coconut Fiber (gr)	Corn Cobs (gr)	Sample Code
1 : 1 (10 g : 10 g)	4	6	A
1 : 1 (10 g : 10 g)	6	4	B
3 : 2 (30 g : 20 g)	15	15	C

The matrix is dissolved first by mixing epoxy resin and hardener in the ratio specified in Table 1. After that, the fiber is weighed according to the specified sample, then the fiber mixture is placed in the resin solution while stirring until evenly distributed.

4. Specimen Testing
   The tests in this research used the impedance tube method to determine the sound dampening coefficient. Testing is carried out in a certain frequency range. This frequency will be converted into sound intensity units, namely decibels (dB). Meanwhile, outside the impedance tube, a sound level meter (sound intensity measuring instrument) will also be prepared. The reduction in sound intensity obtained will become data that is processed to find the sound dampening coefficient value.
5. Drawing conclusions
   A conclusion is a short, clear and systematic statement of all the results of discussion and testing in a study. Drawing conclusions is needed to answer the objectives of the research results. Following is the flowchar for all stages:

3. Result and Discussion

The stages of making a composite made from coconut fiber and corn cobs as a noise reducer are as follows:

1. Preliminary treatment stages for fiber

At this stage, researchers took coconut fiber and corn cobs from the surrounding environment, apart from reducing waste, they also used materials that came from nature and developed them into composite materials that would be used as sound absorbers. In the initial stage, the fiber is prepared and given pretreatment, starting from taking fiber from coconuts and corn, cleaning the fiber and drying.

The coconut fiber chosen was old coconut fiber because the water content in the coconut fiber was very low. This is because young coconuts contain high levels of water and when drying, weathering occurs. Peeling coconut fiber still uses a manual system, namely by using a hammer and by hand. This manual method makes work slow. To overcome this, it is necessary to develop or make a tool to peel coconut fiber.

2. Stages of Fiber cutting

After the process of separating the coconut fiber from the coconut fruit and the corn cobs from the corn, it is then cut manually with scissors.

Figure 1. Fiber Cutting Process

The coconut fiber has been cut, then the fiber is cleaned from the coir that remains on the surface of the fiber. Meanwhile, the corn cobs that have been taken are in the form of fine powder and then the two ingredients are soaked in water for approximately 10 minutes as in Figure 2. After that, drained. and dried under the hot sun for 1 day. After the coconut fiber and corn cobs are completely dry, they are mixed with NaOH.

Figure 2. Soaking corn cobs (A) and coconut fibers (B) with water

3. Soaking Stages with NaOH

The completely dry coconut fibers are then soaked in a mixture of 5% NaOH for approximately 4 hours, then drained and dried in the sun until dry. This soaking aims to minimize the amount of extractive substances such as a layer of wax on the fiber in the form of lignin and dirt in the fiber (8). These stages are also carried out to extract fiber from corn cobs.

Figure 3. Soaking fiber with NaOH

Figure 4. Drying the fiber under the sunlight

After obtaining coconut fiber and corn cobs, the two were then mixed in various ways to see the effect of the fiber composition of the composite material on the sound dampening ability.

4. Mixing Stages between Matrix and Coir

The matrix used in this research is epoxy resin and hardener in a ratio of 2:1. For this type of matrix and resin, the mixture ratio was varied to see the influence of fiber and matrix content on the mechanical properties and the magnitude of the influence on the sound dampening characteristics of the fiber sample. Variations of these comparisons are presented in table 2.

Table 2. Comparison Matrix and Filler

Comparison Filler : Matrix	Coconut Fiber (gr)	Corn Cobs (gr)	Sample Code
1 : 1 (10g : 10g)	4	6	Sampel A
1 : 1 (10g : 10g)	6	4	Sampel B
3 : 2 (30g : 20g)	15	15	Sampel C

Before the mixing process, coir and marix are weighed to obtain the desired ratio. Then stir in a mixing bowl. After that, filler is mixed in a predetermined ratio into the matrix which has been mixed thoroughly.

5. Pressing stages with a hydraulic press machine

After mixing thoroughly, the mixture of matrix and fiber is poured into the base of the mold and then leveled, then the plastic on the top of the mold is trimmed so that it completely covers the top of the mixture of matrix and fiber. After that, the mold is closed and pressed using a hydraulic press machine (9).

Figure 5. Composite pressing process with a hydraulic press machine

After the pressing process, the composite is first dried under the heat of the sun until the composite part becomes hard, then the composite mold is broken using a saw or grinding machine so that the composite that has been made can be taken out and then dried again under the heat of the sun until the composite is completely dry.

Figure 6. Results of making samples A, B and C.

Sound Absorption Coefficient Measurement

Testing the damping ability of composite boards is carried out using an audio frequency device which functions to provide sound at the desired frequency and a sound level meter which functions to measure noise or sound levels in decibels (dB). From this impedance tube, it will be possible to calculate the sound absorption coefficient of a medium (10).

Sound absorption coefficient is the sound absorption efficiency of a material at a certain frequency against the sound that comes to that material. This coefficient is expressed in α. The α value can be between - and 1. The smaller the sound absorption coefficient value, the more sound is reflected and the greater the sound absorption coefficient value, the better the sound absorption. The absorption coefficient of an acoustic material will depend greatly on its characteristics, including: The density of the material, the modulus of elasticity, the water content and the speed of sound hitting the material. If the value of this coefficient is large (more than 0.2), then the material will be called a sound-absorbing material. On the other hand, if this coefficient is small (less than 0.2), it will be called a reflecting material (11).

There are 3 composite samples that will be tested, namely samples A, B, and C with different comparisons in the composition between matrix and filler. The sound frequencies given are 125 Hz, 250 Hz, 500 Hz, 1,000 Hz, 2,000 Hz and 4,000 Hz. The test was carried out by measuring the noise level in the chamber before and after the composite material was installed. The loss value is obtained by subtracting the sound level entering the chamber before the acoustic media is installed and the sound received/reflected after the acoustic media (composite sample) is installed (12). The test equipment and testing process can be seen in Figure 7.

Figure 7. Test Equipment (Impedance Tube)

The sound absorption coefficient test results are in the form of test data from specimens with a composition consisting of samples A, B and C. The inlet frequencies are 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz.

Table 3. Results of Measurement of Attenuation / Loss (dB)

Frequency (Hz)	**Soundproofing Capability Measurement Results (dB)**								
	Sample A			**Sample B**			**Sample C**		
	Before	***After***	***Loss***	***Before***	***After***	***Loss***	***Before***	***After***	***Loss***
125	42,8	47,4	-4,6	42,8	45,7	-2,9	42,8	45,1	-2,3
	43	45,8	-2,8	43	46,5	-3,5	43	45,4	-2,4
	45,6	47,1	-1,5	45,6	46,1	-0,5	45,6	45,6	0
	46,1	46	0,1	46,1	45,9	0,2	46,1	45,7	0,4
	43,2	46,6	-3,4	43,2	46,7	-3,5	43,2	44,2	-1
Average	44,14	46,58	-2,44	44,14	46,18	-2,04	44,14	-2,04	44,14
250	64,8	46,6	18,2	64,8	46,8	18	64,8	45,4	19,4
	66	47,6	18,4	66	45,5	20,5	66	44	22
	66,3	48,9	17,4	66,3	47,4	18,9	66,3	43,2	23,1
	66,4	46,1	20,3	66,4	46,4	20	66,4	43,6	22,8
	66,5	49	17,5	66,5	46,9	19,6	66,5	45	21,5
Average	66	47,64	18,36	66	46,6	19,4	66	44,24	21,76
500	95,1	70,3	24,8	95,1	66,9	28,2	95,1	60,8	34,3
	94,8	67,4	27,4	94,8	66,1	28,7	94,8	58,5	36,3
	93,8	71,9	21,9	93,8	64,1	29,7	93,8	57,4	36,4
	94,1	70	24,1	94,1	64,6	29,5	94,1	58,6	35,5
	94,2	71,4	22,8	94,2	65	29,2	94,2	60,1	34,1
Average	94,4	70,2	24,2	94,4	65,34	29,06	94,4	59,08	35,32
750	85	54,5	30,5	85	49,2	35,8	85	46,4	38,6
	84,8	52,4	32,4	84,8	47,9	36,9	84,8	47,2	37,6
	85,2	53,7	31,5	85,2	49,5	35,7	85,2	47	38,2

	84,9	51,3	33,6	84,9	48,	36,7	84,9	48	36,9
	84,4	52,4	32	84,4	49,4	35	84,4	47,2	37,2
Average	84,86	52,86	32	84,86	48,84	36,02	84,86	47,16	37,7
1000	81,1	68,1	13	81,1	67,7	13,4	81,1	66,6	14,5
	84,1	68,3	15,8	84,1	66,1	18	84,1	62,8	21,3
	84	70,5	13,5	84	64,2	19,8	84	63,4	20,6
	5,4	69,5	15,9	85,4	65,2	20,2	85,4	61,4	24
	85,8	69,2	16,6	85,8	66,4	19,4	85,	64	21,8
Average	84,08	69,12	14,96	84,08	65,92	18,16	84,08	63,64	20,44
2000	64,6	66	-1,4	64,6	64,6	0	64,6	64,4	0,2
	65	67,1	-2,1	65	63,5	1,5	65	61,5	3,5
	64,9	66	-1,1	64,9	65,9	-1	64,9	64,9	0
	65	62,2	2,8	65	61,9	3,1	65	60,6	4,4
	64,9	68,8	-3,6	64,9	67	-2,1	64,9	63,3	1,6
Average	64,88	65,96	-1,08	64,88	64,58	0,3	64,88	62,94	1,94
4000	62,4	70	-7,6	62,4	68,1	-5,7	62,4	66,8	-4,4
	61,4	69,4	-8	61,4	67,9	-6,5	61,4	65,6	-4,2
	62,2	68,5	-6,3	62,2	68,1	-5,9	62,2	64,9	-2,7
	63	67,1	-4,1	63	64,2	-1,2	63	60,1	2,9
	63,1	67,9	-4,8	63,1	66,6	-3,5	63,1	62,5	0,6
Average	62,42	68,58	-6,16	62,42	66,98	-4,56	62,42	63,98	-1,56

Source: Measurement Results

Table 3 provides information related to the sound absorption capacity (loss value) for each specimen with the thickness and sound frequency level given to the test specimen. For example, when giving a frequency of 125 Hz, with five repetitions the incoming sound/energy has a noise level of 42.3 dB; 43 dB; 45.6 dB; 46.1 dB; and 43.2 dB with an average of 44.14 dB.

Loss = sound/energy arrives (before) – sound/energy is received/reflected (after)

Meanwhile, the sound/sound absorption coefficient is obtained by:

$$\propto = \frac{Wa}{Wi} = \frac{absorbed\ sound}{coming\ sound\ or\ energy}$$

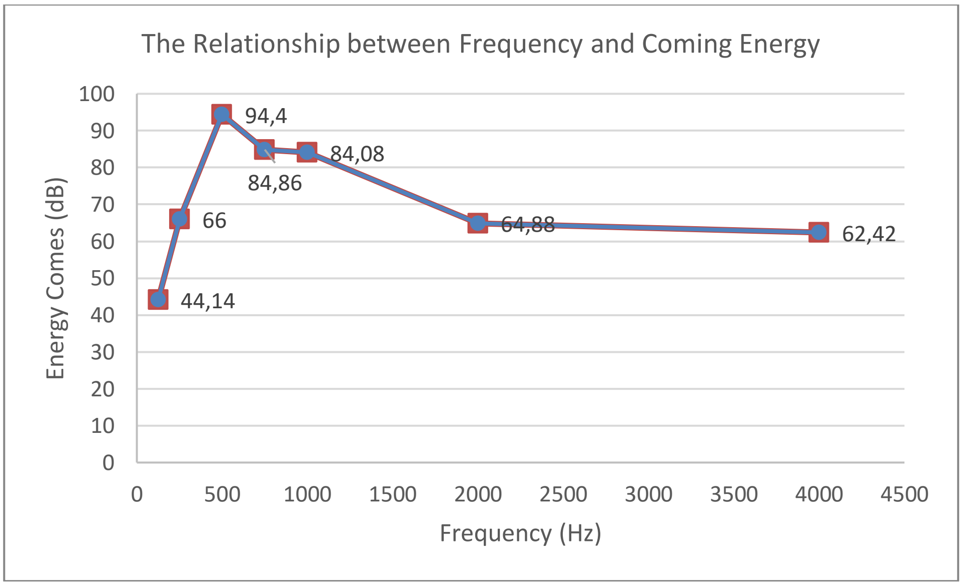

Figure 8. Energy Comes based on Sound Frequency

The sound dampening ability results show varying values for each test specimen. The highest incident sound/energy after averaging was 94.4 dB at a frequency of 500 Hz, while the lowest incident sound/energy after averaging was 44.14 dB at a frequency of 125 Hz.

Meanwhile, the highest sound/energy absorption (loss) (average value) was 37.7 dB at a frequency of 750 Hz in sample C. Meanwhile, the lowest sound/energy absorption was -6.16 dB at a frequency of 4000 Hz in sample A.

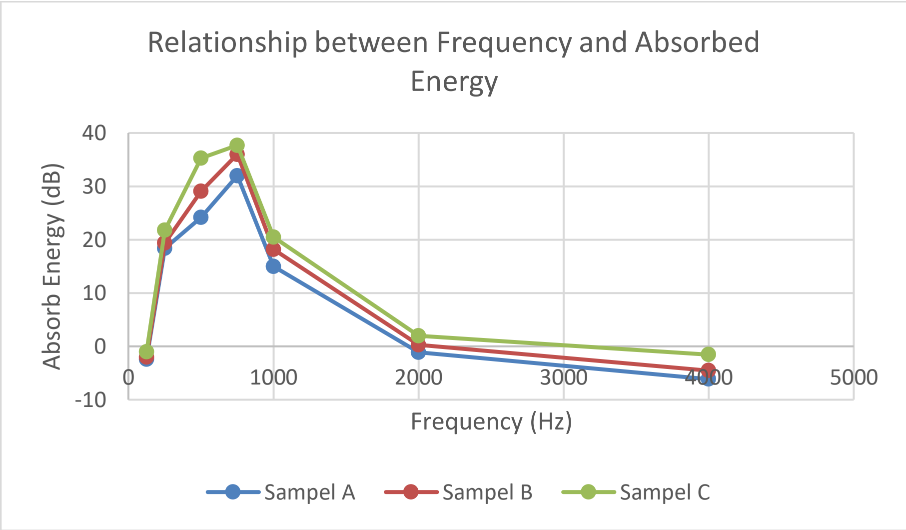

Figure 9. Absorbed Energy based on sound frequency

For more clarity, see table 4.

Table 4. Average value of damping ability (loss)

Frequency (Hz)	Energy Comes	Absorb Energy (loss)			Absorption Coefficient		
		A	B	C	A	B	C
125	44.14	-2.44	-2.04	-1.06	-0.055	-0.046	-0.024
250	66	18.36	19.4	21.76	0.278	0.294	0.33
500	94.4	24.2	29.06	35.32	0.256	0.308	0.374
750	84.86	32	36.02	37.7	0.377	0.424	0.444
1000	84.08	14.96	18.16	20.44	0.178	0.216	0.243
2000	64.88	-1.08	0.3	1.94	-0.017	0.005	0.03
4000	62.42	-6.16	-4.56	-1.56	-0.099	-0.073	-0.025

The absorption coefficient value shows varying results, this is because the specimens tested are not homogeneous. What influences the non-homogeneity of composite materials can be caused by several factors, namely in theory composites are made from two or more constituents that do not dissolve in each other, the mixing process is not homogeneous causing the results to be non-uniform. throughout the part so that it tends to produce large porosity. The louder the sound, the more likely a material with a high density to reflect it (13).

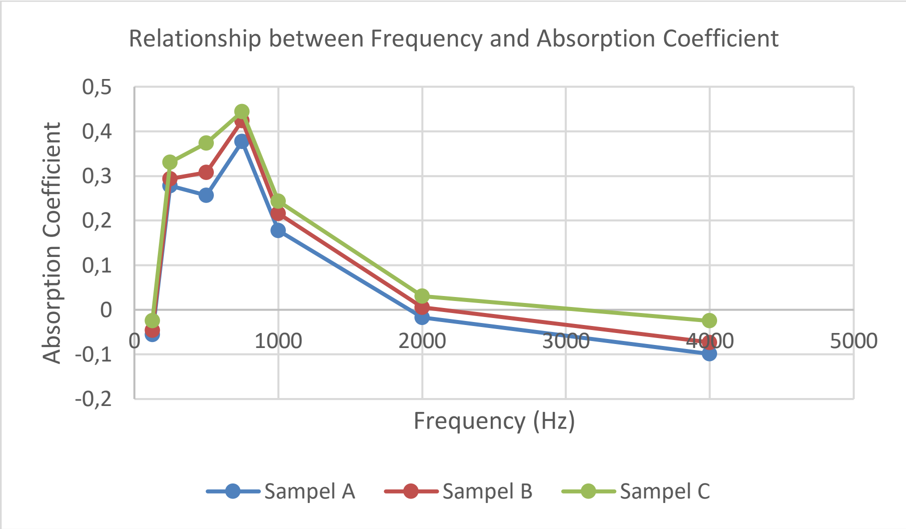

Figure 10. Sound Absorption Coefficient based on Frequency

From table 4 and picture 10 it shows that the sound absorption coefficient values obtained at frequencies of 125 Hz, 2000 Hz and 4000 Hz in all variations of samples A, B and C produce poor values because they are <0.2. The sound absorption coefficient values obtained at frequencies of 250 Hz, 500 Hz and 750 Hz for all variations of composite specimen samples produced good values (≥ 0.2). Meanwhile, the frequency of 1000 Hz has different sound absorption for each variation. The variation in sample A shows poor values (< 0.2) while samples B and C show good sound absorption coefficient values (≥ 0.2).

From the results of this composite acoustic test obtained for samples A, B and C, it can be seen that the lowest sound dampening ability/absorption coefficient (α) is -0.099 for sample A with a frequency of 4000 Hz and the highest is 0.444 for sample C at a frequency of 750 Hz.

4. Conclusion

Based on the results of data processing and analysis, the following conclusions can be drawn:

a. The sound dampening ability results show varying values for each test specimen. The highest incoming sound/energy is 94.4 dB at a frequency of 500 Hz while the lowest incoming sound/energy is 44.14 dB at a frequency of 125 Hz. Meanwhile, the highest sound/energy absorption (loss) (average value) was 37.7 dB at a frequency of 750 Hz in sample C, while the lowest sound/energy absorption was -6.16 dB at a frequency of 4000 Hz in sample A.
b. The sound absorption coefficient values obtained at frequencies of 125 Hz, 2000 Hz and 4000 Hz in all variations of samples A, B and C produced poor values because they were <0.2. The sound absorption coefficient values obtained at frequencies of 250 Hz, 500 Hz and 750 Hz for all variations of composite specimen samples produced good values (≥ 0.2). Meanwhile, the frequency of 1000 Hz has different sound absorption for each variation. The variation in sample A shows poor values (< 0.2) while samples B and C show good sound absorption coefficient values (≥ 0.2). From the results of this composite acoustic test obtained for samples A, B and C, it can be seen that the lowest sound dampening ability/absorption coefficient (α) is -0.099 for sample A with a frequency of 4000 Hz and the highest is 0.444 for sample C at a frequency of 750 Hz.

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