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Comparison of Sound Absorption Coefficient on Natural Fiber and Recycle Materials Panel

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Abstract: Nowadays, there are various types of natural fiber produced to applied as sound absorption panel. These natural material-based panels have a lot of competition with synthetic materials. The absorbent material in the sound absorption panel is an important material to reduce noise production. The objective of this study is to identify past research on natural fiber expansion based on acoustic panels, to analyze Sound Absorption Coefficient (SAC) data at low frequency (1000 Hz) as well as to compare the best results. There are natural fibers such as coconut fiber, kapok fiber, rice husk fiber, sugarcane bagasse, wheat straw fiber, palm oil frond, wool fiber and coir while the recycle material are shredded paper, sawdust, crumb rubber, eucalyptus globulus leave, natural rubber, recycle paper and recycle rubber. The parameter studied is the value of the sound absorption coefficient at low frequency are density and thickness. The parameters referred to in this study are data from previous researchers related to the test of impedance tubes to obtain the value of sound absorption coefficient. This study is for a comparison of acoustic panels based on natural fibers and recycled materials. The results show palm oil frond with natural rubber has the highest sound absorption coefficient which is 0.96 compare to other materials. The thickness of an acoustic panel made of palm oil frond with natural rubber also the thickest which is 50 mm while the density is 350 kg/m^3. There is a relationship between sound absorption coefficient and thickness and also density. The higher the sound absorption coefficient, the higher the thickness and the higher the density. The results encourage that natural fiber is good sound absorption material and still capable to be used as acoustic panel.

Keywords: Sound Absorption Panel, Natural Fiber, Low Frequency

1. Introduction

Noise defines as the sound produced at the wrong time and place. Thus, noise pollution can be interpreted as unwanted noise that spreads into the atmosphere regardless of the adverse effects that will occur [1]. Therefore, there is a demand to produce alternative products that can be used to reduce noise pollution at various frequency levels. An alternative to producing a sound-absorbing panel using

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natural fibers as well as waste materials. Most sound absorbing panels are made up of synthetic fibers. Synthetic fiber is a substance that is dangerous to human health. Synthetic fibers contain a variety of chemical mixtures [2]. Also, sound absorbing panels made of synthetic fibers are quite expensive in the market despite their small size.

There are many researchers who have made acoustic panels using natural fibers such as wheat straw, kenaf fiber, cotton fiber, kapok fiber and sugarcane fiber. Sound absorbing panels made of fiber are very nice and good. In addition, natural fiber is low cost, renewable, readily available and does not harm the environment and human health [3].

Acoustic panels made of natural fibers have their own special features. For example, rice straw is suitable for acoustic panels because of its high elasticity and hollow space [4]. While coconut fiber has good sound absorption at higher frequencies but less for lower frequencies [5]. Furthermore, kenaf fibers have good sound absorption performance in normal and random occurrences [6]. Sound absorption panels made from these natural fiber materials need to be competitive with sound absorption panels made from synthetic materials available in the market. This is because, natural fiber materials are more assured of consumer safety [7]. Natural fiber materials do not contain any chemicals to produce sound absorption panels while, sound absorption panels made from synthetic materials contain chemicals that can affect the health of consumers.

The absorbent material in the sound absorption panel is an important material to reduce noise production. A large number of acoustic panels now contain expensive chemicals for research and development, and it is also in the manufacture of products. Furthermore, chemicals can pose a danger to human health. Meanwhile, synthetic materials derived from chemicals are unsustainable and require complex machines to mix. Alternatively, natural fiber materials can be used as a reliable source that can absorb sound production

Acoustic panel is a sound-absorbing panel that is usually placed on the wall or ceiling to control and reduce noise, echo and act to absorb heat. In addition, acoustic absorption refers to the process by which sound waves face surfaces such as walls, floors, seats, building structures and other materials and reflect.

Sound is something produced in the ear by variations in air pressure. These various pressures will transfer energy from the vibration source. Air can be vibrated by various methods. For example, speakers, guitars, and human vocal cords. Sound is a vibrating motion using air. What the ear can actually hear is the vibrations captured by the ear and translated by the brain [8].

The frequency of sound is the number of vibrations per second of molecules of air produced by the vibrating body. A complete movement back and forth of the vibrating body is referred to as a 'cycle' [9]. Frequency is expressed as the number of cycles per second (cps); it is also referred to as Hertz (Hz).

The sound absorption coefficient for each material varies according to frequency. It is common practice to list material coefficients at frequencies of 125, 250, 500, 1000, 2000, and 4000 Hz of sound absorption coefficients contributed by α. The higher the number of coefficients, the better its absorption.

The scope for this study was to study sound absorption panels that contain natural fibers and mix with waste materials. This is to ensure that the sound absorption panel is appropriate in marketing. The other scopes in this study are effectiveness of sound absorption panels on the walls and ceiling of buildings, natural fiber material used to produce sound absorption panels, the value of the coefficient is only at low frequency, the impedance tube is performed to compare the sound absorption coefficient data and analysis using Microsoft Excel software.

This study focuses on how to overcome the problem of noise pollution in enclosed areas such as rooms, halls and auditoriums by using sound absorption panels produced from natural fibers, namely coconut fiber, sugarcane fiber, kenaf fiber and kapok fiber.

The aims of this study are to identify previous research studies on the expansion of natural fibers based on acoustic panels, to analyze Sound Absorption Coefficient (SAC) data at low frequency and to compare the best results among the natural fiber.

2. Materials and Methods

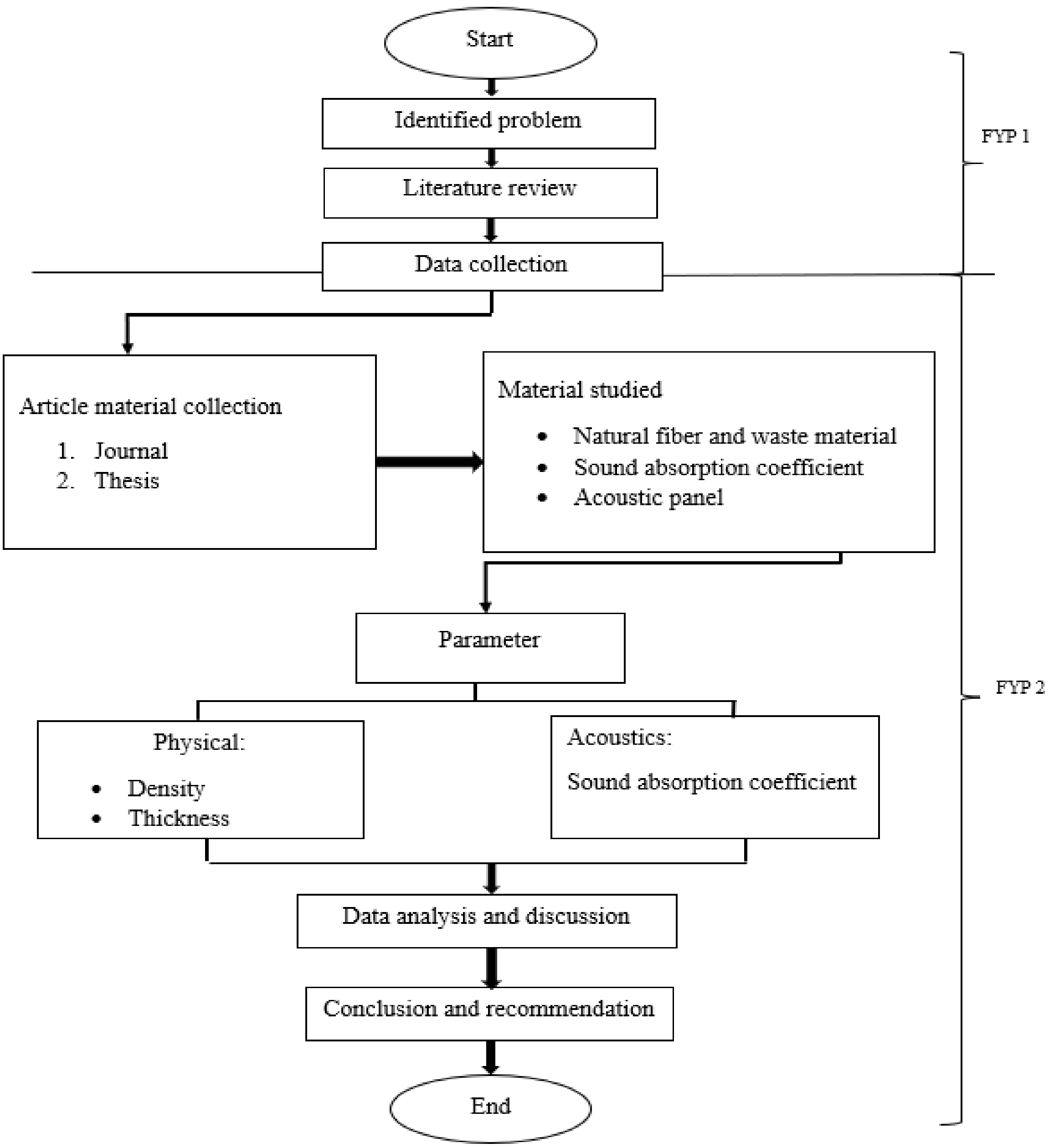

Figure 1: Methodology chart

3. Results and Discussion

The results in Table 1 shows the value of sound absorption coefficient, thickness and even density of natural fiber materials from 10 journals. The value of the sound absorption coefficient data is summarized to make it easier to determine the best materials to produce acoustic panels at low frequencies below 1000 Hz. Next, the density values and thickness values to determine side effects on the acoustic panel were also analyzed. Table 1 shows the position of natural fiber from the highest to lower sound absorption coefficient, α.

Table 1: Example of presenting data using a table

No.	Natural fibers	Sound absorption coefficient, α @ low frequency (1000 Hz)
1	Palm oil frond and natural rubber [10]	0.96
2	Wheat straw fiber and eucalyptus globulus leaves [11]	0.95
3	Coconut fiber and natural rubber [10]	0.93
4	Coconut coir and rice husk fiber [7]	0.85
5	Scrap wool and recycle paper [12]	0.65
6	Coconut fiber and recycle rubber [13]	0.58
7	Steel fiber and crumb rubber [14]	0.32
8	Rice husk fiber and sugarcane bagasse [4]	0.32
9	Coconut fiber and shredded paper [5]	0.27
10	Kapok fiber and sawdust [15]	0.24

3.1 Sound absorption coefficient, α

Figure 3 shows the values of sound absorption coefficient, α for all the materials that has been reviewed. Based on the graph in Table 1, the value of the sound absorption coefficient for a highest acoustic panel is 0.96 at low frequency. The materials for the highest coefficient values are palm frond fiber and natural rubber. The material details used for the production of acoustic panels are 80.0 % palm frond fiber and 20.0 % natural rubber. Oil palm fronds that show in Figure 2 are potentially the best choice for the production of acoustic panels [10]. Acoustic panels produced with wheat straw and eucalyptus globulus leaves produce a relatively high coefficient value of 0.95. due to the result of the combination of these materials is very suitable for low frequency acoustic panels. Eucalyptus Globulus leaves are a good material for thermal insulation and sound absorbing material that will affect the low environment with no harm to humans [11].

Figure 2: Oil palm frond

Generally, the sound absorption coefficient of the material is between 0 ~ 1. The larger the figure, the better the sound-absorbing properties. According to Peng, the sound absorption coefficient may be more than one value because the effective sound absorber area is greater than the calculated area [16].

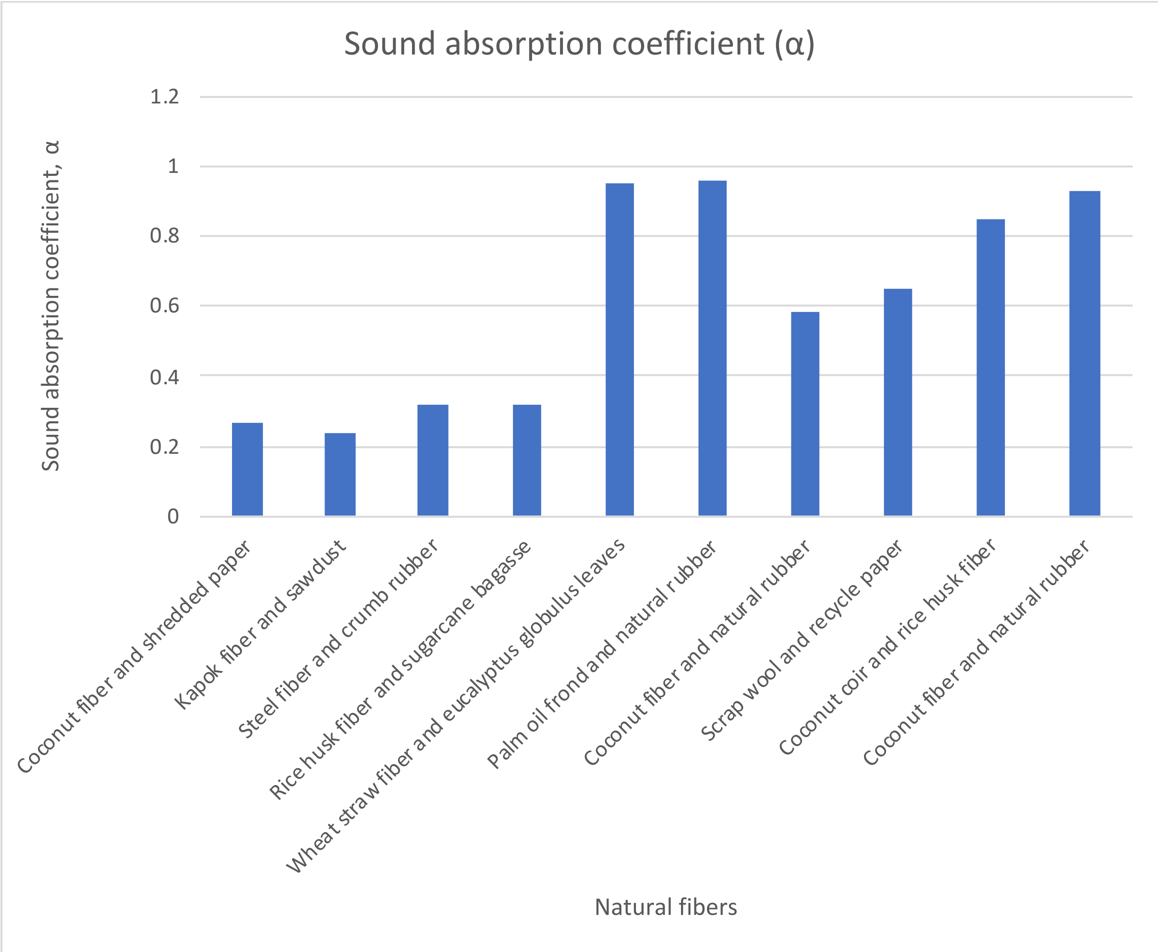

Figure 3: Sound absorption coefficient, α

3.2 Relationship between sound absorption coefficient and density

Figure 4 shows the relationship between sound absorption coefficient and density where it will affect the acoustic panel. The density increases affect the value of sound absorption to increase. This is because the sound absorption increases as the density of the material increases to a certain limit [7]. Too high a density can reduce porosity which in turn increases flow resistance and provides a barrier for sound waves to penetrate the material. There is only a mixture of materials that are steel, and plastic coated with rubber fragments has a relatively high density of 851 kg/m^3 but has a relatively low sound absorption value. This happen based on, the mixture of materials steel fibers which causes high density and affects the low sound absorption coefficient which causes the sound absorption panel to be less effective at low frequency.

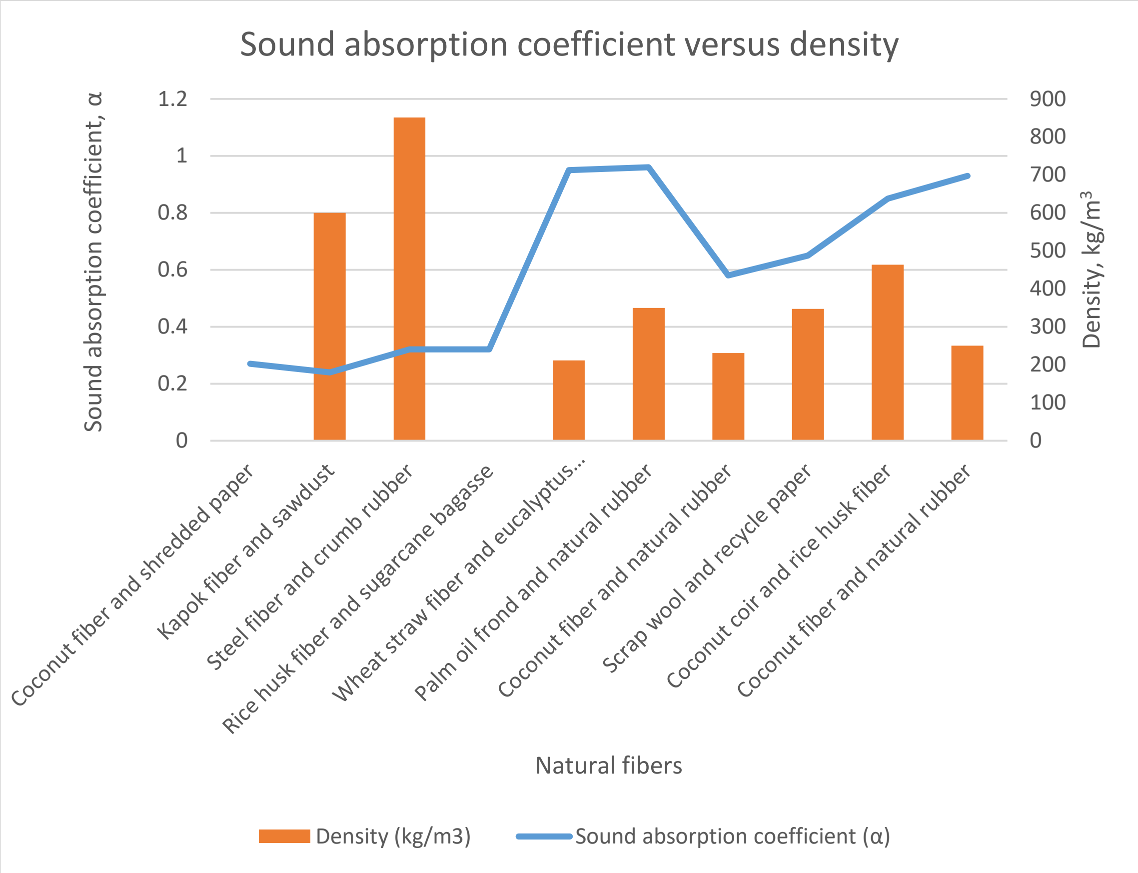

Figure 4: Relationship between sound absorption coefficient and density

3.3 Relationship between sound absorption coefficient and thickness

The thickness of the sample increases and the sound absorption coefficient will also increase for all types of materials as it provides more space for sound waves to remove material with viscous and frictional effects [7]. For materials with same density, an increase in thickness indicates an increased flow direction for the sound absorption coefficient. Based on Figure 5, the highest thickness is 50 mm and has a high value of sound absorption coefficient of 0.96 representing oil palm fronds and natural rubber. Meanwhile, the lowest thickness is 22 mm and has a low sound absorption coefficient value of 0.32.

Based on previous researchers, the percentage difference in thickness can be determined. As much as 60.0 % difference in thickness between the thickest and thinnest. This indicates, significant thickness differences are made for the production of acoustic panels where this thickness plays an important role in determining the sound absorption coefficient [9].

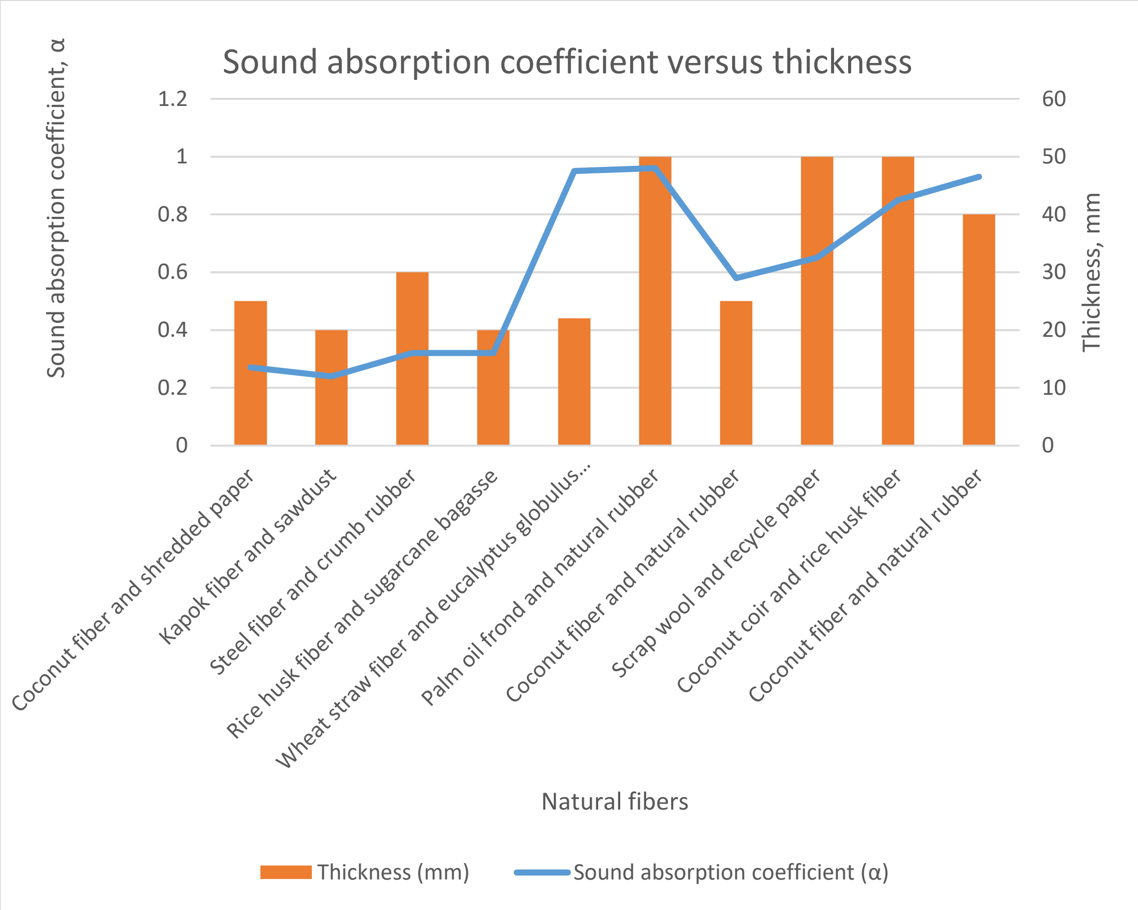

Figure 5: Relationship between sound absorption coefficient and thickness

4. Conclusion

The study is about to choose the best material to produce acoustic panel by using natural fibers and waste material. The best materials are palm oil frond and natural rubber which is achieved 0.96 in sound absorption coefficient. Then, there are parameters that affect the value of sound absorption panel which are density and thickness. The values are 350 kg/m^3 and 50 mm respectively. In conclusion, the higher the value of sound absorption coefficient, the higher the density and the higher the thickness of acoustic panel.

Through the results of this study, all three objectives that have been stated have been achieved. The first objective is to identify past research on the use of natural fibers based on acoustic panels. Research of previous studies has been done by review 10 journals. Based on the 10 journals researched, there are natural fiber materials used in the production of acoustic panels. Among them are palm frond fiber, wheat straw fiber, coconut fiber, fiber, cotton, coconut fiber, rice husk, sugarcane fiber and kapok fiber. Recycled materials are natural rubber, pieces of paper, sawdust, recycled paper, eucalyptus globulus leaves and recycled rubber.

The second objective is to analyze the Sound Absorption Coefficient (SAC) data at low frequency. All data collected from 10 journals were to identify the value of sound absorption coefficient. Therefore, all the data and natural fibers used for the production of acoustic panels have been summarized. Low frequency value range is 250 - 1000 Hz [15].

The third objective is to compare the best acoustic panel among the natural fiber that has been review. Palm frond fiber and natural rubber has the highest sound absorption coefficient. The fiber used has the highest absorption coefficient value of 0.96. The absorption coefficient approaching the value of one is a good value for sound absorption [16].

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