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Biodegradable Materials from Combination of Egg Tray, Oil Palm Empty Fruit Fiber And Paddy Straw as Sound Absorber

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ABSTRACT

Noise is referred as unwanted sound, that is among the most pervasive pollutants today. Ambient noise could be reduced by using acoustic absorbers. The conventional acoustic absorbers are made from synthetic materials which might contribute to global warming and pollutions during its production. Biodegradable materials such as oil palm empty fruit bunch (OPEFB) fiber, paddy straw and egg tray are easily obtained locally. In this study, sound absorption performance of these materials were investigated. Impedance tube and sound reverberation room tests were carried out in this study. In the experimental work for impedance test, at 4000Hz frequency, the combination of paddy straw and egg tray was proved to be a good sound absorber with sound absorption coefficient of 0.97 compared to combination of oil palm empty fruit bunch fiber and egg tray at 0.93. For sound reverberation room, the maximum time value for the room without acoustic panel were 8.01s and 7.05s for microphone 1 and 2, respectively. The maximum time value for egg trays with paddy straw and OPEFB fiber with egg trays for microphone 1 were 4.09s and 4.75s, respectively. For microphone 2, the maximum value for egg trays with paddy straw was 3.52s and egg trays with OPEFB fiber was 3.51s. The experiments that has been carried out showed that egg trays and natural fibers could be a good alternative in replacing synthetic fibers that currently widely used.

Keywords: Sound absorption, egg tray, impedance tube test, OPEFB fiber, paddy straw

1. INTRODUCTION

Acoustic absorber is a material used to absorb sound energy [1]. Recently, the utilization of 'green' and sustainable materials as acoustic absorber is expanding in the research sector due to its benefits over synthetic materials [2][3]. The conventional acoustic absorbers are made of synthetic materials such as rock wool, glass wool and foam glass, which are harmful to the environment and human's health [4][5]. A sound means mechanical wave pressure moving through solids, liquids and gases [6]. It consists the frequency range of hearing, where the level is loud enough to be heard and can stimulate hearing organs due to the resulting air vibration [7]. According to this explanation, the resulting noise is influenced by the medium and the surroundings [8].

Environmental conditions affect the velocity and absorption of sound into the air; even with a small percentage it can have a huge impact on listeners especially in closed areas or rooms [9]. In a closed area, the resulting sound will be absorbed and reflected by the material or equipment around it [10]. Sound absorber can reduce the pressure level, especially in enclosed areas or rooms [11]. Numerous studies have been conducted using natural fibers to explore their potential as sound absorbing materials [12]. The studies include research on wood, paddy straw, paddy husk, wheat straw, bamboo, coconut fiber and palm oil fibers [12-17]. Recycling materials such as used tires can be used other than the use of organic and natural fibers [18].

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The objective of study is (1) identify the sound absorption coefficient (SAC), noise reduction coefficient (NRC) and reverberation time of the egg tray with oil palm empty fruit bunch fibers and egg tray with paddy straw, and (2) determine the better sound absorption between these two type of natural fibers. The impedance tube test and reverberation room test will be conduct in order to the determine the objectives of this study.

2. MATERIAL AND METHODS

2.1 Materials

For this study, paddy straws with egg trays and OPEFB fibers with egg trays were used as absorption materials while plywood and jersey-type fabric as outer layer [19]. Figure 1 shows the materials.

(a) (b) (c) (d) (e)

Figure 1. Materials used in the project, (a) egg trays, (b) OPEFB fibers, (c) paddy straws; (d) Jersey fabric and (e) plywood.

2.2 Experimental Works

2.2.1 Impedance Tube Test

Paddy straw with egg tray and OPEFB fiber with egg tray were tested for the impedance tube test. For this purpose, proper samples must be prepared in a cylinder form by cutting a 100 mm diameter round plywood and then layered using the combination of materials before wrapping with jersey-type fabric. Figure 2 shows the steps to prepare the samples.

Figure 2. The process for sample impedance tube.

This method requires a hard and a round or square portion tube, but it should be equipped with a sound source at its tip and the system for the material sample was mounted at the other end. Microphone was installed on portable probes tube to facilitate this test with different sound distances. The arrangement of the apparatus is shown in Figure 3 [20].

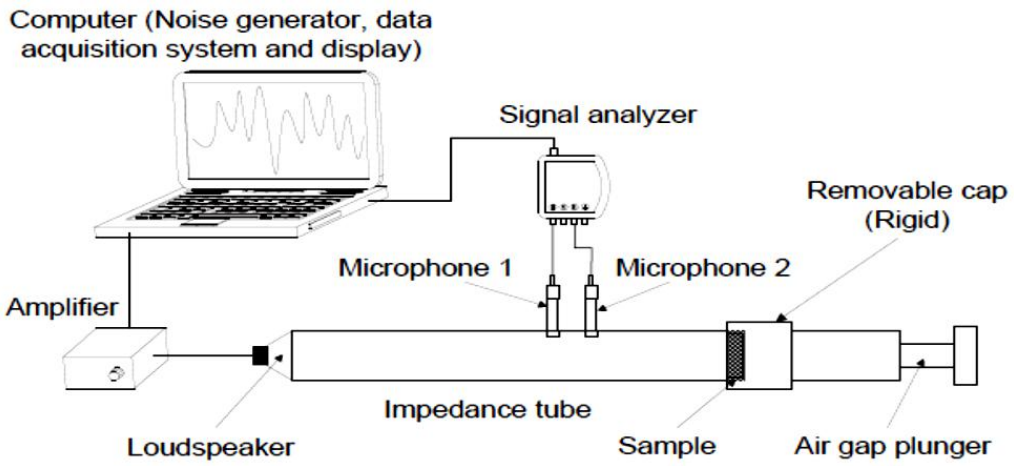


Figure 3. The experimental setup to determine sound absorption coefficient.

2.2.2 Reverberation Room Test

Figure 4 shows the steps and the material used in order to make the acoustic panel. Whereby the complete acoustic panel to be tested in reverberation room.

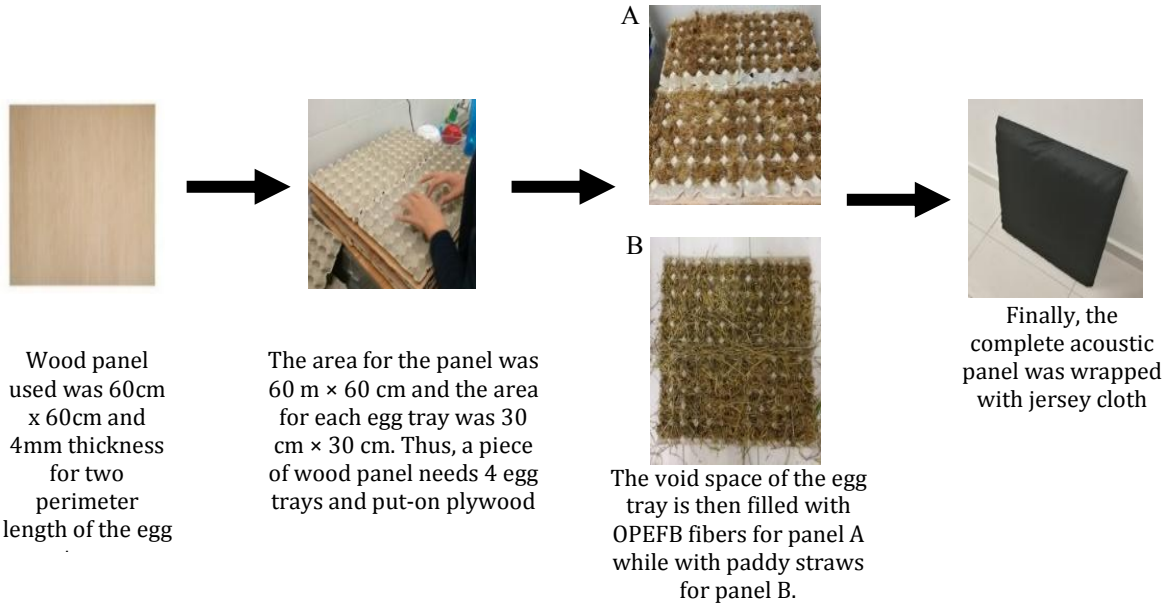
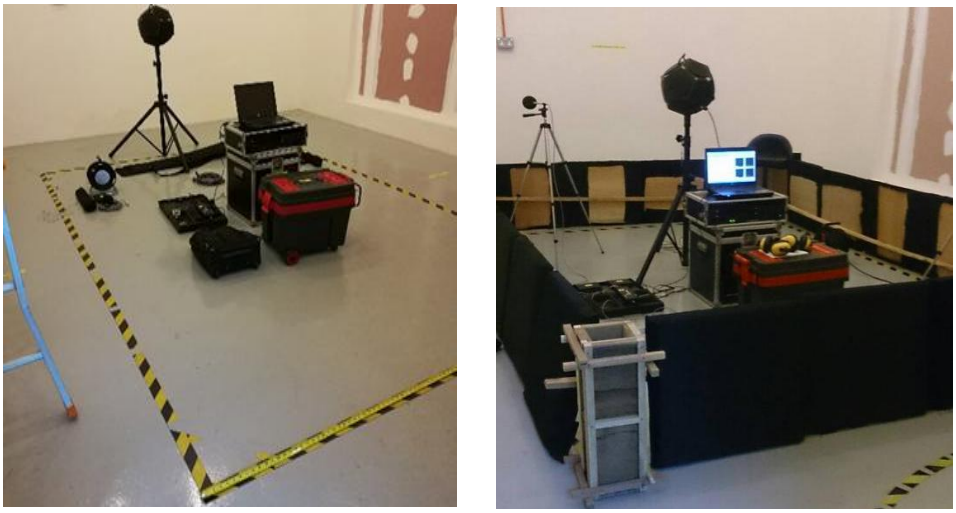


Figure 4. The acoustic panel.

The sound absorber panel was tested at acoustic laboratory in the Faculty of Civil and Environmental Engineering (FKAAS), UTHM. The area of the test area is 2.68 m × 3.75 m, and the overall perimeter requires 24 total panels for paddy straws with egg tray and 24 panels for OPEFB fibers with egg tray. Figure 5 shows the reverberation room without and with panels. Effective sound absorption will depend on the frequency and time value obtained from the test. The effectiveness of sound absorption depends on the time recorded after the test was carried out on the palm oil bunches with egg tray and paddy straw with egg tray.



(a) (b)

Figure 5. The reverberation room, (a) without acoustic panels and (b) with acoustic panels.

3. RESULTS AND DISCUSSION

3.1 Impedance Tube Test (Sound Absorption Coefficient, SAC)

Materials that have a moderate and high degree of absorption coefficient within 0.5 and above are regarded as good sound absorbers, while those with low coefficient 0.49 to 0.2 are good for a sound proof [21]. For impedance tube test, the low frequency detected ranged from 200Hz to 1500Hz. As for high frequency, the range detected was from 200Hz to 6000Hz. Figure 6 shows the results of SAC for both samples.

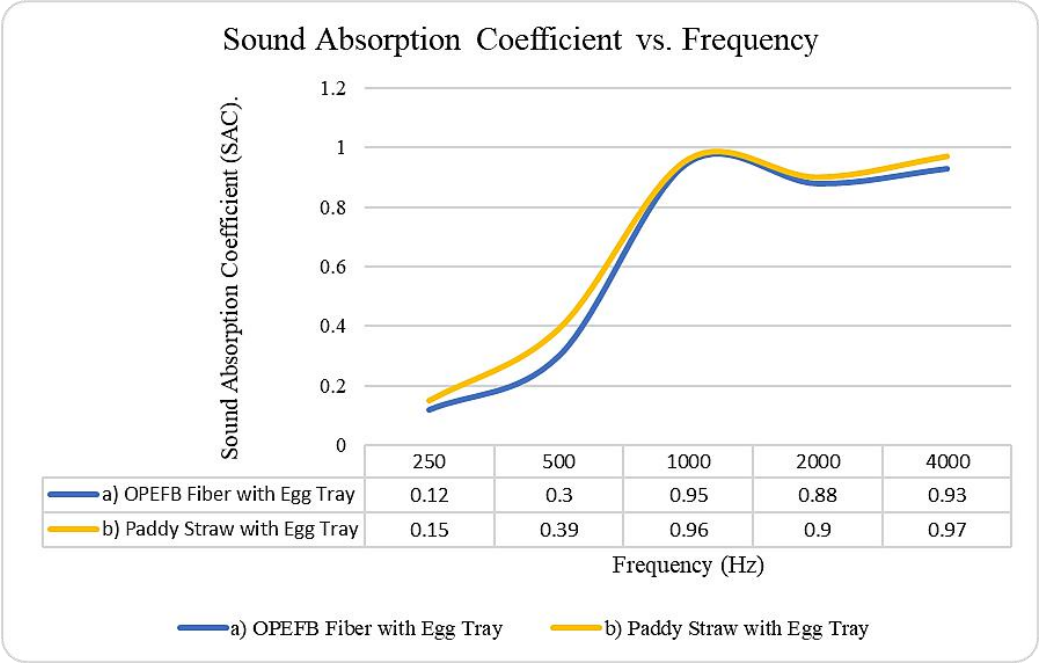


Figure 6. The sound absorption coefficient (SAC) of the material.

According to Figure 6, both studied materials show a good sound absorption coefficient value ranged from 1000Hz to 4000Hz. At low frequency, the readings are poor and result may error, but when the frequency increased, the graphs sound absorption were produced [22]. At the frequency range of 1000Hz to 2000Hz, the coefficient values of paddy straw with egg tray and OPEFB fiber with egg tray showed a decrease from 0.96 to 0.90 and 0.95 to 0.88, respectively. Paddy straw with egg tray and OPEFB fiber with egg tray are good in absorbing sound at high frequency and weak at low frequency.

3.2 Noise Reduction Coefficient (NRC)

NRC is used as a single index to check the effectiveness of the material used as sound absorber and provides a good and as examine how a surface of the study material can absorb human voices [23]. Table 1 shows different NRC values for different natural fibers while Figure 7 shows the comparison between various types of natural fiber [24-26].

Table 1 Different NRC values of natural and synthetic fibers

Type of Materials	NRC	Reference
Coconut Husk (CH) Fiber	0.4	
Corn Cob	0.33	Hosseini et al. (2013)
Grass	0.41	
Sugarcane	0.42	
Egg Tray	0.4	Matt Boughan (2012)
Kapok with Egg Tray	0.57	Kaamin, et al. (2017)
CH fiber with Egg Tray	0.52	Kaamin, et al. (2018)
Paddy Straw with Egg Tray	0.6	
OPEFB Fiber with Egg Tray	0.56	

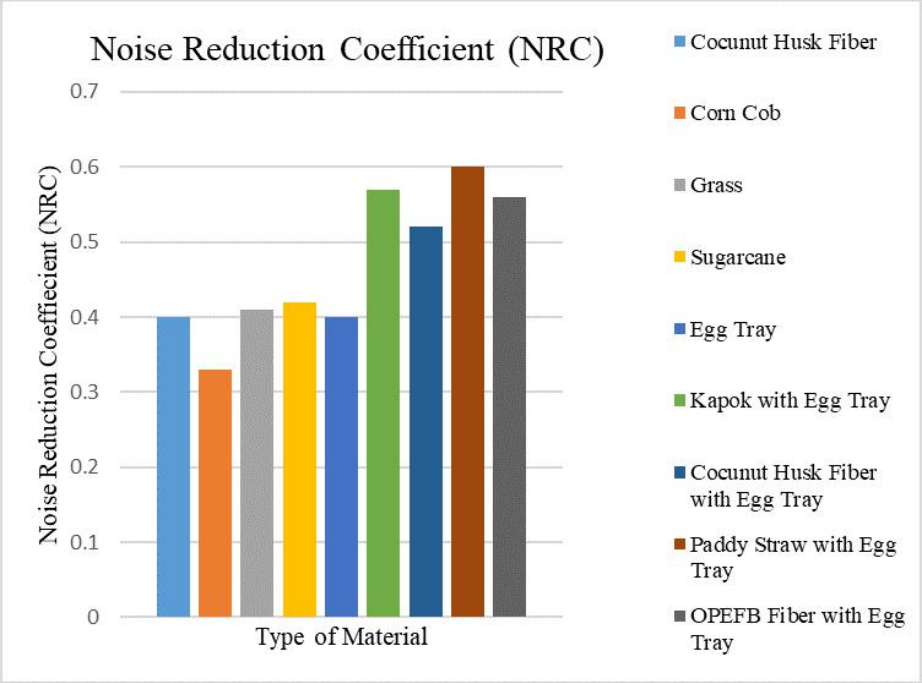


Figure 7. Comparison of NRC among natural fibers.

In this study, the NRC value for paddy straw with egg tray recorded the highest value (0.60) compared to the NRC value of other natural fibers. Hence, the higher the NRC value, the higher the ability of materials to absorb sound. NRC value of paddy straw with egg tray is near to 1.0, and thus it is good for sound absorption. Addition of paddy straw on egg tray improved the value of NRC (0.6) compared to OPEFB fibers with egg tray (0.56).

3.3 Reverberation Room

Figures 8 and 9 show the differences in time value of the reverberation room between materials used as sound absorber panels with different microphone positions. The comparison made between the without any acoustic panel with the panels with OPEFB with egg tray and panels of paddy straw with egg tray. In microphone 1 and microphone 2, the maximum value for the room without acoustic panel is 8.01 s and 7.05 s, at frequency of 315 Hz and 250 Hz respectively. The maximum value for egg tray with paddy straw and egg tray with oil palm bunches fibers in microphone 1 is 4.09 and 4.75, at frequency of 250 Hz and 100 Hz respectively. On the order hand, for microphone 2, maximum value for egg tray with paddy straw each maximum value is

3.52 s at frequency of 100 Hz and 3.51 s at 250 Hz frequency for the panels with OPEFB with egg tray.

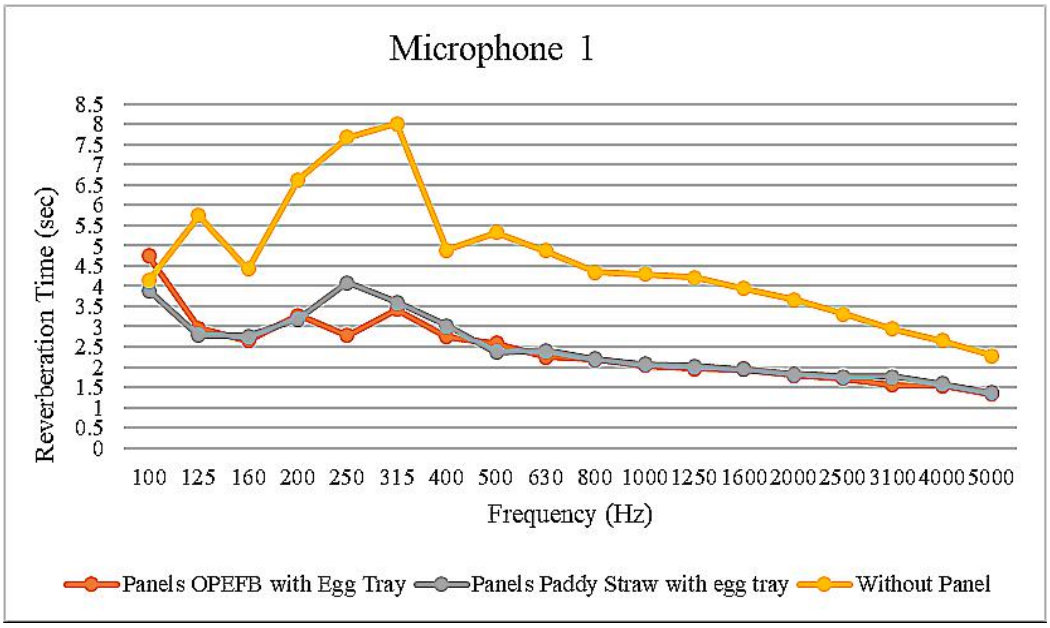


Figure 8. The reverberation time for microphone 1.

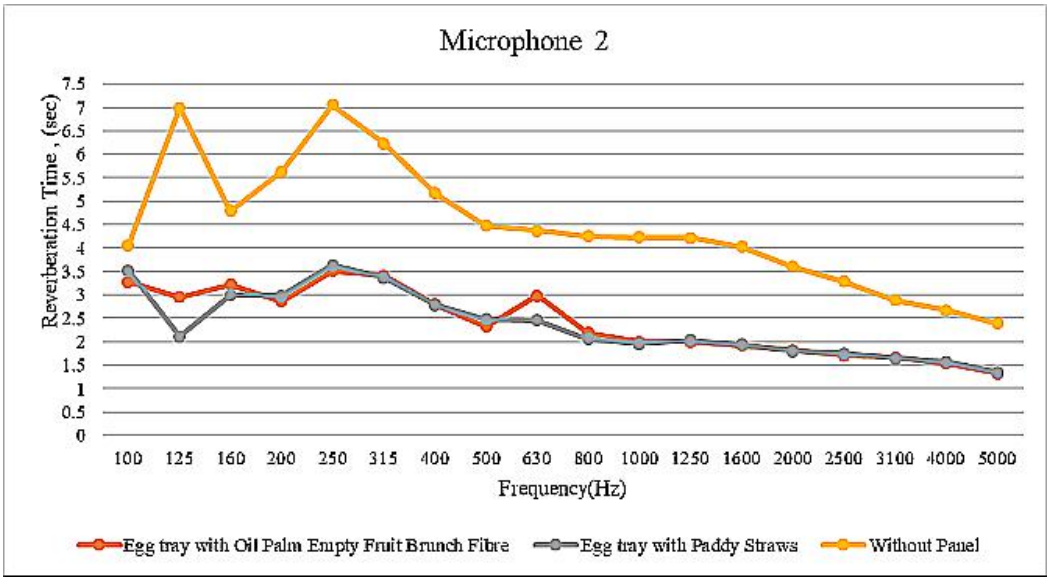


Figure 9. The reverberation time for microphone 2.

Generally, the two panels have a nearly echoic time value. Comparison of results for the loss of the echo value in the room experiment without penalization shows a much different time value compared with a room with panels.

4. CONCLUSION

Based on impedance test, paddy straw with egg tray proved to be a good sound absorber compared to OPEFB fibers with egg tray. Egg tray was used as reinforcing filler to improve environmentally friendly and acoustic absorption properties. Hence, egg tray also is one of the

factors that increase the Noise Reduction Coefficient (NRC). Thus, paddy straws with egg tray have the potential to be used as one of the option as synthetic fibers used in the industrial acoustic material. Paddy straw with egg tray and OPEFB fibers with egg tray have nearly the same value and not much difference in Reverberation Time value. However, the finding shows a significant difference of testing between a room with acoustic panels and a room without acoustic panels. Experiment and analysis that has been carried out showed that the natural fibers and egg trays has the potential to absorb the noise and might be used as the one of the material of acoustic material in the future. However, the research study need to have the further studies and compare with the synthetic fibers that are widely used as commercial sound absorber that will lead to significant results.

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