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Utilization of Plastic Snack Food Packaging Waste as a Sound-Absorbing Composite Material in Buildings Exposed to Sound Pollution

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Abstract

Until now, the conventional problem encountered, namely waste, is still a problem that worsens the environmental conditions of society in Indonesia. Starting from inorganic waste such as plastic to organic waste such as vegetable and fruit waste, it has the same role in reducing the quality of public health. plastic is waste that takes a long time to decompose so that plastic waste is one of the most crucial problems in the current era. One way is to make it an environmentally friendly product, such as the development of absorbent materials or sound absorbers by utilizing plastic waste. Sound pollution is the propagation of noise with ranging impact to the human life. Sound pollution is produced by machines, transport and propagation systems which frequently places in urban area. Sound pollution can lead to the psychological issue and physical issue such as cardiovascular effects and corona artery disease due to the sound intensity. This discussion will focus on plastic snack heaters, namely LDPE (Low Density Polyethylene) plastic. In this research, the community is expected to be able to use plastic waste into goods or products that are more useful to reduce the number of inorganic waste. The research method are literature study which used as the fundamental comprehension to do the plastic waste and composite material research also an experimental method by making four types of panel samples of various plastic waste processing. Comparison variations in the form of differences in the size of plastic pieces 0.5 cm x 0,5 cm, 1 cm x 1 cm and 1,5 cm x 1,5 cm and processed tapioca flour without the addition of pieces of plastic waste that will be tested at sound frequencies 400 Hz, 600 Hz, 800 Hz, 1000 Hz, and 1200 Hz. From all calculation, It obtains that all variation works perfectly in range frequency 400 – 600 Hz. For 800, 1000 and 1200 there are mines coefficient that informs the increasing of sound intensity level instead of reducing noises. For the size, as the pieces of plastic snack packaging food waste size grows up, the better quality of plastic waste composite material gained. It can be investigated in 1 cm x 1 cm and 1,5 cm x 1,5 cm size which almost all appears the positive value of the coefficient of sound absorption. The condition is totally opposite with control and 0,5 cm x 0,5 cm. As the smaller pieces or non pieces, the sound can still propagate easily through the pipe without any obstacles. On the other hand, for 1 cm x 1 cm and 1,5 cm x 1,5 cm size, the sound can not propagate easily through the sample since there are big plastic waste which absorbs the sound. Therefore, the best variations are 1 cm x 1 cm and 1,5 cm x 1,5 cm. By applying regression linear to prove the highest coefficient determination and the equation. By applying the regression linear into 1 cm x 1 cm and 1,5 cm x 1,5 cm, the equation obtained y = -3,258 ln (x) + 22,163 with coefficient determination (R^2) = 0,6304 and y = -2,516 ln (x) + 14,627 with coefficient determination (R^2) = 0,5102. These variations show the decrease exponential by 1 cm x 1 cm is the lowest gradient m = -3,258 compared to the 1,5 cm x 1,5 cm which has gradient m = -2,516. As the lower gradient indicates the higher absorption of noise. On the other hand, The coefficient determination is mathematical tools to indicate how the impact of independent variable for dependent variable. From those calculations, it concludes that the best variation for coefficient of sound absorption parameter and statistical calculation is 1 cm x 1 cm by having R^2 equal 0,6304 compared to the 1,5 cm x 1,5 cm which has R^2 equal 0,5102. It also strongly proves that plastic snack packaging food waste can be one of the material composite by applying 1 cm x 1 cm around of frequency 400-600 Hz.

Key Words *: Coefficient of Sound Absoption, plastic food waste, regression linear, sound Level Intensity*

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INTRODUCTION

Until now, a conventional / hereditary problem that is often encountered, namely waste is still a problem that worsens the environmental conditions of society in Indonesia. Starting from inorganic waste such as plastics and batteries to organic waste such as vegetable, fruit and household waste, they have the same role in reducing the quality of public health. Based on data in 2019 obtained from the Ministry of Environment and Forestry (KLHK), the dominant waste is organic waste with a composition of around 60%, followed by plastic waste with 14% and paper waste amounting to 9% in the third position (Cordova and Nurhati, 2019). Judging from the available data, it can be concluded that inorganic waste in the form of plastic is in the second level after organic waste. At present, plastic waste such as used plastic bottles for drinks, plastic packaging, plastic bags has increased a lot considering their relatively easy production and increasingly widespread use (Ragaert, dkk., 2017). This can become a serious problem over time and of particular concern to the community. Plastic is waste that takes a long time to decompose so that plastic waste is one of the most crucial problems in the current era (Moharir and Kumar, 2019). Plastics that are difficult to decompose over time will only be thrown away and pile up into a growing pile of garbage which will have a negative impact on the environment and health. Therefore, the 3R (Reuse, Reduce, Recycle) method has an important role to play in helping reduce the impact of plastic waste (Davidson, dkk., 2021).

One way is to make it an environmentally friendly product, such as the development of absorbent materials or sound absorbers by utilizing plastic waste. Sound absorbers are materials that can absorb sound energy from a sound source whose function is to control noise (Killeen, dkk., 2023). Noise is sound that comes from industrial activities, trade, power generation equipment, transportation equipment and household activities (Syafrudie and Haryo, 2021). Technology in the form of information, communication, production, transportation, and entertainment facilities is growing very rapidly so that most of the equipment produces noise (Halperin, dkk., 2011). Noise itself has become a problem that needs to be taken seriously. To anticipate this, various types of silencers have been developed. (Khuriati. Et all, 2006). Noise can be reduced by using materials that can reduce and absorb sound. Sound-absorbing materials on the market are mostly made of synthetic materials. One of the criteria for sound-absorbing materials is porous which functions as a cavity resonator. Through these pores sound waves enter and vibrate the air molecules in the pore (Simatupang 2007) One of the efforts to overcome noise in space is the use of acoustic materials. Plastic is one of the materials indicated as a material that reduces noise (Kakar, dkk., 2022). Plastics come in different types which have different characters and uses. This discussion will focus on plastic snack heaters, namely LDPE (Low Density Polyethylene) plastic. LDPE is a type of plastic made from petroleum which is commonly used as a container for food, plastic packaging, and soft bottles (Vijayakumar and Sebastian, 2018). This type of plastic is strong, flexible, resistant to heat, chemicals and has a slightly fatty surface (Sofiana, 2017). In this research, the community is expected to be able to use plastic waste into goods or products that are more useful and useful to reduce the number of inorganic waste. In addition, it is hoped that this research will be able to become an alternative material for effective noise dampening of the vertical elements of buildings by processing plastic waste. As well as being able to contribute ideas in making acoustic materials from processing plastic waste to reduce damage to the earth.

In this research, an experiment entitled " Utilization of Plastic Snack Food Packaging Waste as a Sound Absorbing Composite Material in Buildings Exposed to Sound Pollution" will be carried out. In this research, an experiment will be carried out related to the management of plastic waste into an alternative material for space acoustics. This plastic waste composition will be combined with tapioca flour to get the right variation of some of the best room acoustics.

LITERATURE REVIEW

Currently, there are many studies that have the aim of utilizing waste into an environmentally friendly product. One of them is the development of absorbent materials or space noise absorbers by utilizing waste waste or using environmentally friendly materials such as in research conducted by Anam et al. (2019) which discusses the use of used cloth waste as soundproof partition walls. The purpose of this study was to obtain effective results of room attenuation by utilizing used cloth waste. The method used to determine the value of sound reduction and absorption coefficient is a method of measuring sound from various positions with variations in the type of fabric and variations in the shape of the room. The various types of fabrics are wool, denim and cotton fabrics. While the shapes of the shapes are cubes, cones and tubes. The optimum results obtained in the measurement position of the side, the shape of the cube space, and the type of cloth are wool with a noise reduction percentage of 35.38% from 80 dB to 51.7 dB.

The next research is a research conducted by Khuriati et al. (2006) in which this study aims to determine the sound absorption power of the coconut fiber composite. Absorbent materials have been prepared with different compositions from coconut coir composites. Twelve samples have been made. One example is natural coconut coir and the other is made of coconut coir and coconut coir with a certain composition. From 12 samples, 10 samples have been tested. The absorption coefficient was measured by the impedance tube method with the ASTM E-1050: 1990 standard. The test results showed that coconut husk met the absorbent material standard according to ISO 11654, namely with an absorption weight (aw) above 0.15. The sample absorption weights are, A: 0.30; B: 0.44; C: 0.27; D: 0.44; E: 0.51; F: 0.44; G: 0.47; H: 0.49; I: 0.31; A: 0.41. So samples A, B, D, E, F, G, H, I and J can be classified in class-D while sample C is in class-E. The absorber material that has been made is also compatible with the product being marketed. The best absorber composition is a mixture of coconut coir and coir fiber. Increasing the amount of coir fiber increases the maximum absorption. Adding an air cavity between the sample and the wall increases absorption. Increasing the mass density of a sample with a similar total mass composition and a similar glue increases absorption at low frequencies.

From these studies, it can be seen that the utilization of both organic and inorganic waste can become a material in reducing noise. So based on this research, there is a novelty that will be carried out in this study, namely by using a combination of tapioca flour and plastic waste. And in this study will use parameters in the sound confession of making room acoustics based on variations in composition.

METHODOLOGY

Tools and Materials

The tools used in this research are scissors, knife, ruler, pan, gas stove, measuring cup, spoon, scale, printed container, oil plastic, smartphone, sound level meter apps, frequency generator apps, speaker and pipe. The materials used in this research are plastic waste, tapioca flour, and water.

Research Steps

This research was conducted in two stages, the first stage was making samples and the second stage was testing samples of room sound absorbers.

Sampling Stage

The sampling stage begins with cutting 3 meter sheet of plastic snack packaging into sizes 0,5cm x 0,5cm, 1 cm x 1 cm and 1,5 cm x 1,5 cm. The plastic sheet is chopped into small pieces according to the predetermined variations. Then 100ml of water to a boil, mix with 30 grams of tapioca flour per sample, stir evenly until thickened like adhesive. The results of the small pieces of plastic are then mixed evenly with the adhesive from tapioca flour so that the plastic pieces stick together properly. The plastic mixture with adhesive is printed on a mold container measuring pipe diameter 4 x 4 inch with a thickness of 1 cm. In order for the sample to be easily removed from the mold, before pouring the mixture, the mold container should be lined with plastic. The drying process is carried out using sunlight, the samples are dried in the sun to dry then released from the mold.

Testing Stage

The first test is carried out by measuring the decibel amount, then the prepared sample will be installed in the middle of the pipe while each of end is placed by sound measurement (Sound Level Meter Apps) and sound generator (Frequency generator). After installing those tools, data collection was carried out by providing a sound source to each sample for once a minute at a predetermined frequency. So that it can be seen the level of sound reduction by evaluating the sound intensity of each sample to the given frequency. The testing process is carried out by testing each sample at a sound frequency of 400 Hz, 600 Hz, 800 Hz, 1000 Hz, and 1200 Hz.

Formula

To obtain the result, the data will be analyzed by using fundamental sound intensity level equation below.

$$I = I_0 e^{-\alpha x} \quad (1)$$

Equation (1) can be derived to this equation below.

$$\alpha = -\frac{1}{x} ln\left(\frac{I}{I_0}\right) \quad (2)$$

With :

α = Sound Absorption Coefficient (m^{-1})

x = thickness of sample (uniformly 1 cm)

I = Sound intensity Level (dB)

I_0 = Initial Sound Intensity Level (dB) (Campillo-Davo, dkk., 2013)

By applying this formula to this research, coefficient of sound absorption will be obtained as the result also the effective interval of frequency range of plastic waste packaging food composite absorbing material. To determine the best absorption composite material, the interval of sound absorption coefficient is ranged by 0 – 1. If the sound absorption coefficient reaches zero, the material will not absorb the sound at all vice versa. As the coefficient of sound absorption increases, the better quality of composite material gained. To determine the best variation, regression linear is applied to investigate how the impact of independent variable for dependent variable by observing the coefficient determination (R^2) also the gradient (Schneider, dkk., 2010). Therefore, the best result from coefficient of sound absorption and statistic parameter are gained.

RESULTS AND DISCUSSION

Research Data

In this study, there were 4 variations in the composition of mixing tapioca flour with plastic waste. The variations carried out were variation 1, namely control (without the addition of plastic waste. Variation 2 with a ratio between tapioca flour and plastic waste measuring 0,5cm x 0,5cm, variation 3 with a size of 1cm x 1cm, and variation 4 with a size of 1.5cm x 1.5cm. Data collection Each sample is carried out once for one minute at each frequency The testing process is carried out by testing each sample at a sound frequency of 400 Hz, 600 Hz, 800 Hz, 1000 Hz, and 1200 Hz. All data can be seen in the table below.

Table 1. Data Measurement Results of Each Sample

NO	Frequency (Hz)	Initial Sound Intensity (dB)	Sound Intensity Level (dB) variation			
			Control	0,5cm x 0,5cm	1cm x 1cm	1,5cm x 1,5cm
1	**400**	83,3	81,1	81,4	81,6	82,4
2	**600**	82,2	81,5	82,2	80,5	81,2
3	**800**	81,5	82,4	81,5	80,4	80,2
4	**1000**	80,9	79,2	80,9	82,5	81,8
5	**1200**	80,8	82,7	80,8	81,2	81,6

This data will be examined by applying the formula (2) to gain the best coefficient of sound absorption among all variations. This result will be explained further in result and discussion section.

Result and Discussion

This study aims to determine how much sound reduction value is generated from each sample made, and to find out how plastic waste processing techniques are capable of reducing noise by investigating their size of plastic waste. The composition of this plastic waste will be combined with tapioca flour to get the right variation from some of the best room acoustic samples. In determining the appropriate variation, 4 variations of the composition of tapioca flour and plastic waste were mixed. The variations carried out were variation 1, namely control (without the addition of plastic waste. Variation 2 with the ratio between tapioca flour and plastic waste measuring 0.5cm x 0.5cm, variation 3 with a size of 1 cm x 1 cm, and variation 4 with a size of 1.5cm x 1.5cm. variations in each sample, data collection will be carried out once for one minute at each frequency. Data collection is carried out by providing a sound source to each sample for once a minute at a predetermined frequency. The testing process is carried out using a Sound Level Meter apps with test each sample at a sound frequency of 400 Hz, 600 Hz, 800 Hz, 1000 Hz, and 1200 Hz which produced by Frequency Generator apps. Data taken are in the form of decibels from each sample in order to obtain the level of noise reduction (Noise Reduction) at that sound frequency. The overall data obtained can be seen in table 1. From the table, it indicates that almost all variation provides less sound intensity level after applying the composite of plastic packaging food waste. It also states that the effective frequency for applying plastic packaging food waste as the composite material around of 400 – 800 Hz. For 1000-1200 Hz, the material is out of the frequency which leads to the increasing of sound level intensity. Therefore, plastic waste composite only works for 400-800 Hz instead of 1000-1200 Hz. By applying the formula (2), the coefficient of sound absorption is appeared as the table 2.

Table 2. Data Measurement Sound Absorption Coefficient of Each Sample

NO	Frequency (Hz)	Sound Absorption Coefficient (1/m)			
		Control	0,5cm x 0,5cm	1cm x 1cm	1,5cm x 1,5cm
1	**400**	2,676559	2,307328	2,061929	1,086311
2	**600**	0,855228	0	2,089812	1,224005
3	**800**	-1,09824	0	1,358884	1,607951
4	**1000**	2,123753	0	-1,95845	-1,10634
5	**1200**	-2,32426	0	-0,49383	-0,98523

Table 2 shows that for plastic which has 0,5 cm x 0,5 cm size have zero coefficient which leads to unchanged condition between before and after applying the material. All variation works perfectly in range frequency 400 – 600 Hz. For 800, 1000 and 1200 there are mines coefficient that informs the increasing of sound intensity level instead of reducing noises. This table also provides the information that as the pieces of plastic snack packaging food waste size grows up, the better quality of plastic waste composite material gained. It can be investigated in 1 cm x 1 cm and 1,5 cm x 1,5 cm size which almost all appears the positive value of the coefficient of sound absorption. The condition is totally opposite with control and 0,5 cm x 0,5 cm. As the smaller pieces or non pieces, the sound can still propagate easily through the pipe without any obstacles. On the other hand, for 1 cm x 1 cm and 1,5 cm x 1,5 cm size, the sound can not propagate easily through the sample since there are big plastic waste which absorbs the sound. Therefore, the best variations are 1 cm x 1 cm and 1,5 cm x 1,5 cm.

To determine the best from those two variations, it will be examined by applying regression linear to prove the highest coefficient determination and the equation. By applying the regression linear into 1 cm x 1 cm and 1,5 cm x 1,5 cm, the equation obtained y = -3,258 ln (x) + 22,163 with coefficient determination (R^2) = 0,6304 and y = -2,516 ln (x) + 14,627 with coefficient determination (R^2) = 0,5102. These variations show the decrease exponential by 1 cm x 1 cm is the lowest gradient m = -3,258 compared to the 1,5 cm x 1,5 cm which has gradient m = -2,516. As the lower gradient indicates the higher absorption of noise. On the other hand, The coefficient determination is mathematical tools to indicate how the impact of independent variable for dependent variable. From those calculations, it concludes that the best variation for coefficient of sound absorption parameter and statistical calculation is 1 cm x 1 cm by having R^2 equal 0,6304 compared to the 1,5 cm x 1,5 cm which has R^2 equal 0,5102. It also strongly proves that plastic snack packaging food waste can be one of the material composite by applying 1 cm x 1 cm around of frequency 400-600 Hz.

CONCLUSION

The best variation is plastic food packaging waste which has 1 cm x 1 cm size by having y = -3,258 ln (x) + 22,163 with coefficient determination (R^2) = 0,6304. This variation is effective to be applied at the frequency around of 400-600 Hz.

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