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Acoustic characterization of farm residues for sound absorption applications

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ABSTRACT

Synthetic materials used for acoustic absorption are now a days replaced by natural materials in order to improve the environmental health. In particular, The farm residues have been considered as valid raw material to manufacture sound absorbing panels with low cost. These materials have no harmful effect to human health, and are available in plentiful as waste product in agriculture farming cycle. Considering the Review of literature of previous studies carried out by many authors on acoustic performance of naturally available farm residues, this paper reports the acoustical performance of the some farm residues as Lobia shell, Coconut leaf, Urad dhal Leaf, Sugarcane Leaf and Maize. The Sound absorption coefficient for different samples with varying thickness have been measured. This study reveals that the Acoustic performance of the farm residues as absorption panel are appreciable in the mid-range of frequency spectrum considered for study. The Scanning electron Microscope images are also analyzed to understand the structure of the farm residues considered in this study.
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1. Introduction

Noise levels are to be reduced greatly in places such as Auditorium, conference halls, cinema halls, hospital and industries to make human feel comfort. Due to environmental issues, the use of Synthetic glass becomes restricted to be used as insulation material. The environmental implications and health issues related with these materials has turned the attention of researcher towards the natural materials [1–3]. There are few studies about the prediction of sound absorption behavior of natural materials. The materials with high porosity will allow the sound in their matrix so as to easily absorb it and dissipate. Sound usually travel in non-vacuum or in inner space [4]. Sound is considered as mechanical energy which will always travel in the path with least resistance to the outer surface from the source. Materials having open pores are able to absorb more sound than the one with closed pores due to continuity of adjacent pores [5]. Natural fibers have been receiving increasing attention for acoustic uses [6–8]. Many natural fibers for building applications have begun being commercialized already, but the majority of products studied in this paper is still rarely utilized in building acoustic suppression. The materials used for this study are mainly Farm residues derived from agriculture waste to get basic components, which were then compacted to make sound absorbing boards. The attention towards the usage of farm residues for acoustical applications is getting increased [6–8]. When green composites have better mechanical performance than the synthetic one, it seems to be a good alternative to apply in automobile body panels. kenaf-fiber-reinforced core by a thin halogen-free flame-retardant layer was proved to be a better candidate with respect to mechanical performance and fire properties [9]. Value addition is given to agriculture farm residues when it is used as building products than used as fuel or mulch. There has been considerable interest among researchers in developing composite board products with bagasse fiber [10]. This paper focuses on natural materials that are available as waste from farmers. The largely available these wastes becomes problem for farmers when it comes to its disposal, and their usage as absorbing materials will reduce their burning, further mitigating the environmental impact.

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2. Experimental details

2.1. Materials

Materials selected for the study are: (i) Lobia Shell (ii) Coconut Leaf (iii) Urad Dhal (iv) Sugarcane leaf and (v) Maize. Lobia shell is used as feed stock after the dhal is separated. It is otherwise burned in farms making the environment polluted. Coconut leafs are used for thatching of huts in villages of India. Due to its less requirement, Disposal of it becomes very cumbersome job for farmers. Urad dhal is another lentil available in india as abundance. Sugarcane leafs are left in the field after its harvesting. Farmers are disposing it by incineration process causing environmental impact. Maize, even though a source of cattle feed stock, is usually available in large quantity during monsoon season when conservation becomes hard. Considering the availability and disposal problems of the above farm residues, This paper proposes to use them as sound absorbing materials in the form of panels. The Fig. 1 Shows the various farm residues used in this study.

2.2. Specimen preparation

All the samples were prepared in ISO 10534–2 Standard. The following procedure was adopted for preparation of samples of this study

1. The raw material is sundried for removing moisture that may be present in the materials.
2. The material are chopped to shorter sections and then fed into the grinder to make it finer.
3. The obtained s fibers are then sieved in the sieves set to obtain uniform size of 0.5 to 0.9 mm
4. According to the required sample thickness, the sample whole mass is planned which is molded of fibers and resin. Then, based on the essential resin content percentage of the whole sample mass, the fibers and resin masses are subtracted. The resin used is urea formaldehyde.
5. Then, the mixtures were compressed in a mould with a diameter of 100 mm for low frequency and 28 mm for high frequency by applying pressure over a period of time.
6. The final sample shown in Fig. 1 is then cooled down in air before being used in measurement phase.

2.3. Sound absorption test

The impedance tube is used for measuring the sound absorption coefficient. The Fig. 2 shows the measurement set used in this

Fig. 2. Impedance tube set up for Sound absorption coefficient measurements.

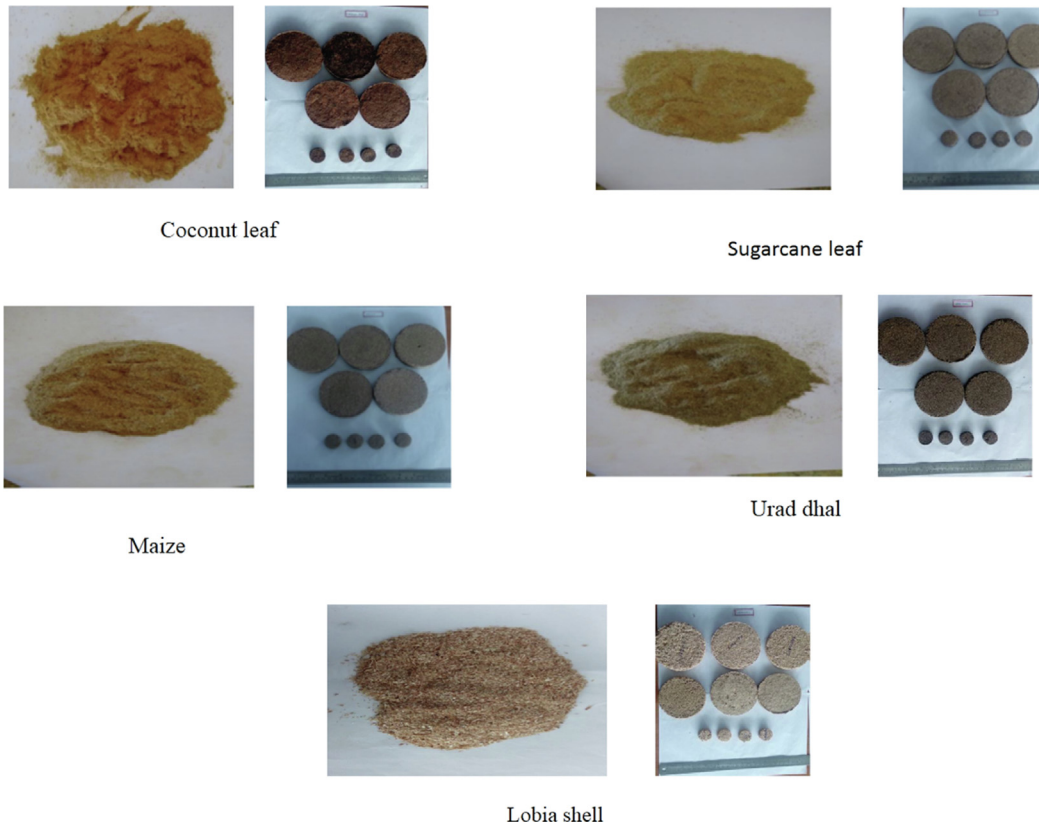

Fig. 1. Specimen details (a) Coconut leaf (b) Sugarcane leaf (c) Maize (d) Urad dhal leaf (e) Lobia shell.

study in accordance with ASTM E1050-98. The sample is kept in the middle of the tube and in one side the loud speaker is mounted and in another side two micro phones are mounted. The microphones was calibrated with a noise generator from a speaker.

3. Result and discussion

3.1. Sound absorption coefficient

The Table 1 gives the sound absorption performance of the Farm residues studied in this paper for the frequency range of 0 to 1500 Hz.

3.1.1. Lobia shell

The lobia, is scientifically known as Vigna unguiculata. The lobia is called by the name of the black-eyed pea, black-eyed bean, or goat pea, a legume, and is a subspecies of the cowpea, cultivated around the world for its medium-sized, edible bean. The common commercial variety is called the California Blackeye. In India it is cultivated as inter crop. The outer layer of the dried lobia is burnt after removal of the beans inside it. The Fig. 3 shows the sound absorption properties of lobia shell particle boards in the frequency range of 0 to 1600 Hz. It is observed that at high at medium and high frequencies, the observed values of the sound absorption coefficient were high but the absorption coefficient values are low at low frequency. The samples of varying thickness 5 mm, 10 mm,

Table 1
Sound absorption coefficients for low frequency range.

Material	Thickness (mm)	Frequency(Hz)				
		125	250	500	1000	1500
Lobia shell	5	0.09	0.1	0.11	0.15	0.34
	10	0.1	0.11	0.13	0.16	0.36
	15	0.14	0.12	0.16	0.18	0.39
	20	0.16	0.13	0.18	0.2	0.41
Coconut Leaf	5	0.05	0.06	0.07	0.08	0.52
	10	0.07	0.08	0.09	0.1	0.58
	15	0.09	0.1	0.1	0.14	0.61
	20	0.1	0.12	0.14	0.17	0.66
Urad dhal	5	0.06	0.07	0.09	0.1	0.55
	10	0.08	0.09	0.1	0.14	0.6
	15	0.09	0.1	0.14	0.16	0.61
	20	0.1	0.12	0.16	0.18	0.61
Sugarcane Leaf	5	0.04	0.05	0.06	0.06	0.5
	10	0.05	0.06	0.07	0.08	0.51
	15	0.06	0.07	0.08	0.09	0.51
	20	0.08	0.07	0.09	0.1	0.54
Maize	5	0.04	0.04	0.05	0.06	0.44
	10	0.05	0.06	0.06	0.08	0.49
	15	0.06	0.065	0.07	0.09	0.51
	20	0.07	0.08	0.09	0.11	0.5

The Table 2 gives the sound absorption performance of the Farm residues studied in this paper for the frequency range of 2000–6000 Hz.

Table 2
Sound absorption coefficients for high frequency range.

Material	Thickness (mm)	Frequency (Hz)								
		2000	2500	3000	3500	4000	4500	5000	5500	6000
Lobia shell	5	0.36	0.67	0.68	0.69	0.71	0.68	0.66	0.65	0.61
	10	0.38	0.69	0.7	0.71	0.75	0.7	0.68	0.66	0.6
	15	0.4	0.71	0.74	0.75	0.78	0.71	0.69	0.66	0.63
	20	0.42	0.75	0.76	0.77	0.79	0.76	0.68	0.64	0.61
Coconut Leaf	5	0.58	0.56	0.57	0.59	0.6	0.58	0.57	0.55	0.54
	10	0.6	0.58	0.56	0.57	0.58	0.56	0.55	0.54	0.53
	15	0.65	0.64	0.63	0.64	0.66	0.61	0.6	0.58	0.56
	20	0.69	0.67	0.65	0.66	0.68	0.67	0.65	0.64	0.63
Urad dhal	5	0.59	0.62	0.61	0.64	0.66	0.65	0.64	0.63	0.61
	10	0.65	0.67	0.66	0.65	0.67	0.66	0.65	0.64	0.62
	15	0.65	0.69	0.68	0.67	0.69	0.67	0.64	0.61	0.61
	20	0.69	0.71	0.7	0.68	0.67	0.66	0.63	0.62	0.61
Sugarcane Leaf	5	0.51	0.49	0.48	0.47	0.51	0.49	0.48	0.46	0.45
	10	0.54	0.5	0.49	0.48	0.52	0.51	0.49	0.47	0.46
	15	0.56	0.51	0.5	0.49	0.5	0.49	0.48	0.46	0.45
	20	0.59	0.56	0.54	0.51	0.62	0.6	0.59	0.56	0.54
Maize	5	0.49	0.5	0.51	0.5	0.52	0.48	0.46	0.44	0.42
	10	0.51	0.5	0.49	0.57	0.58	0.51	0.5	0.52	0.49
	15	0.54	0.51	0.5	0.69	0.72	0.67	0.65	0.61	0.59
	20	0.58	0.59	0.61	0.75	0.76	0.69	0.64	0.62	0.6

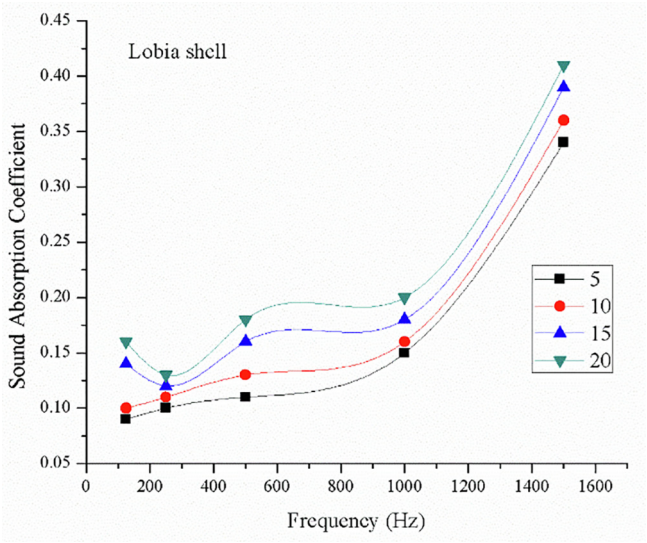

Fig. 3. Absorption coefficient of Lobia shell samples with different thickness for Low frequency.

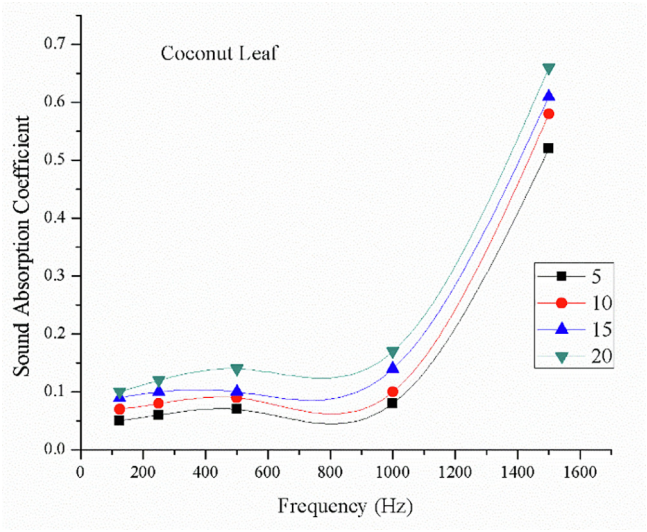

Fig. 5. Absorption coefficient of Coconut leaf samples with different thickness for Low frequency.

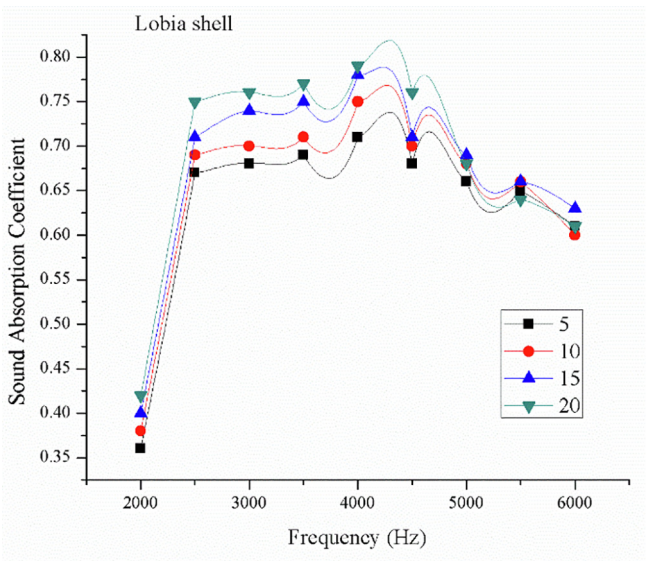

Fig. 4. Absorption coefficient of Lobia shell samples with different thickness for High frequency.

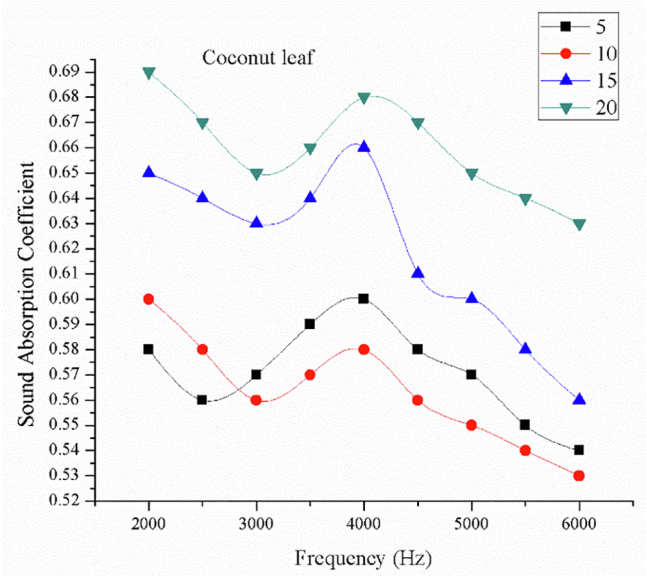

Fig. 6. Absorption coefficient of Coconut leaf samples with different thickness for High frequency.

15 mm and 20 mm were tested for its sound absorption properties in the frequency range of 125 to 6000 Hz.

The Fig. 4 depicts the sound absorption properties of lobia shell for high frequency range. The sound absorption characteristics are appreciable good in the high frequency range. From the figure it can be seen that increase in thick of boards absorbs more sound

3.1.2. Coconut leaf

The coconut tree, scientifically known as Cocos nucifera, is a member of the palm tree family (Arecaceae) grown all over the world for its fruit. The woven coconut leaves are used In India as pandals (temporary sheds) for marriage functions especially in the states of Kerala, Karnataka, and Tamil Nadu. But many of the leaves are finding it difficult to dispose them. This paper aims to find the alternative way to use them effectively. These leaves are crushed into fine particle by shredder and compacted to the ISO Standard to test its sound absorbing capability. Sound absorption properties of is excellent [8]. The Fig. 5 shows the sound absorption characteristics of coconut leaf from the frequency 125 Hz to 1600 Hz. The sample with 5 mm thickness has the absorption coefficient as 0.05 at the frequency of 125 Hz and 0.5 at 1500 Hz. The 20 mm thick sample has

The Fig. 6 shows the performance of coconut leaf samples in the higher frequency range. From 2000 hz to 3000 hz frequency range the absorption coefficient of all thickness variants has a decreasing trend. While the performance of all the samples is seen to be good At 4000 Hz, it stars reducing slightly thereafter.

3.1.3. Urad dhal shell

Urad Dhal is also called as Black Gram. It has its origins in ancient India where it was first cultivated and has remained a staple ever since. The shell of urad dhal after separating the grains are left in the field as waste. This study attempts to find the alternative usages of it as sound absorption panel in buildings.

The Fig. 7 depicts the performance of urad dhal shell acoustic panels of different thicknesses. The absorption coefficient of 5 mm thick panel at 125 Hz is 0.05 and the panel having thickness of 20 mm has the absorption coefficient value as 0.1. The panels show better performance at 1600 Hz with values of SAC 0.5 and 0.65 when the thickness of the samples increased from 5 mm to 20 mm.

The sound absorption characteristics of lobia shell panels are shown in Fig. 8.The performance of the panels are appreciably good at high frequency range. From 2500 Hz to 6000 Hz the absorption of panels shows consistent performance. Sugarcane leaf

Saccharum officinarum, sugarcane, is a large, strong-growing species of grass in the genus Saccharum. It is the major cash crop in India. When Farmers burn the leaves after harvesting causes environmental problem by adding dust to the air. It affects the daily life of major cities like Delhi leaving the people to struggle to breathe. It is the need of the hour in countries like India to find an alternative method to dispose the leaves with out burning. The paper studied the use of leaves in panels for acoustic absorption. Fig. 9 shows the acoustic performance of the panels manufactured from sugarcane leaf waste materials.it can be seen that the values are between 0.05 and 0.55 when the frequency for tests varied from 125 Hz to 1600 Hz. It is deduced that all the samples are more efficient in high frequency range i.e. between 1000 Hz To 1600 Hz.

From the Fig. 10, it can be observed the characteristics of the sound absorption panels made from sugarcane leaf. The sound absorption values are between 0.5 and 0.6 at 2000 Hz. The SAC values are having maxima at 4000 Hz for all the samples.

3.1.4. Maize

Maize, scientifically known as zea mays, has become a staple food in many parts of the world, with the total production of maize surpassing that of wheat or rice. The husks of maize is be braided

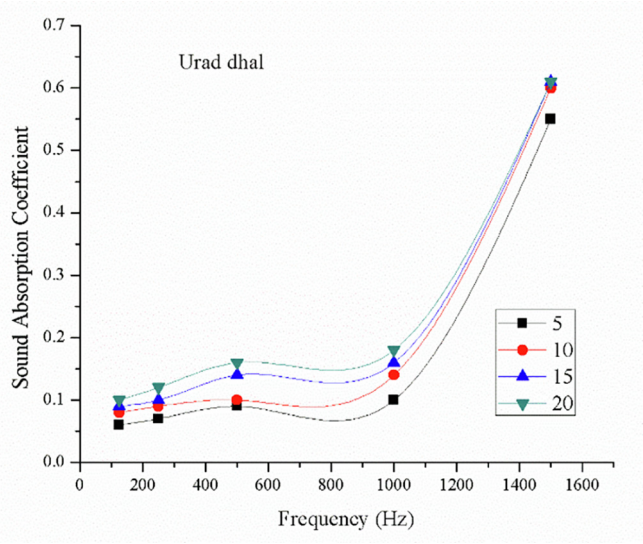

Fig. 7. Absorption coefficient of Urad dhal samples with different thickness for Low frequency.

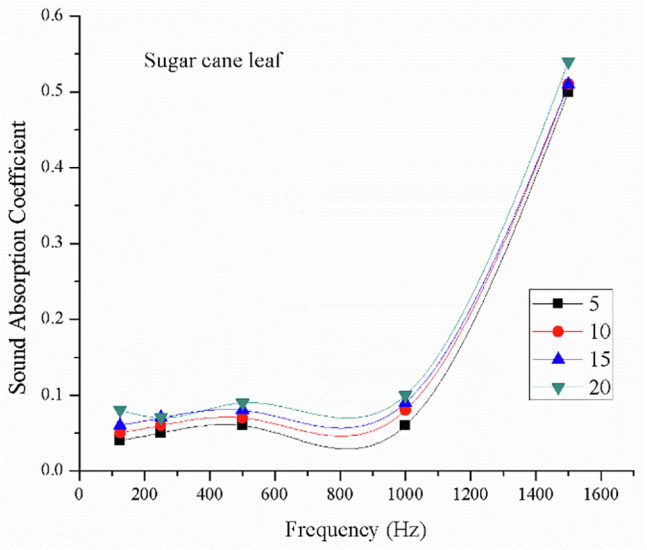

Fig. 9. Absorption coefficient of Sugarcane leaf samples with different thickness for Low frequency.

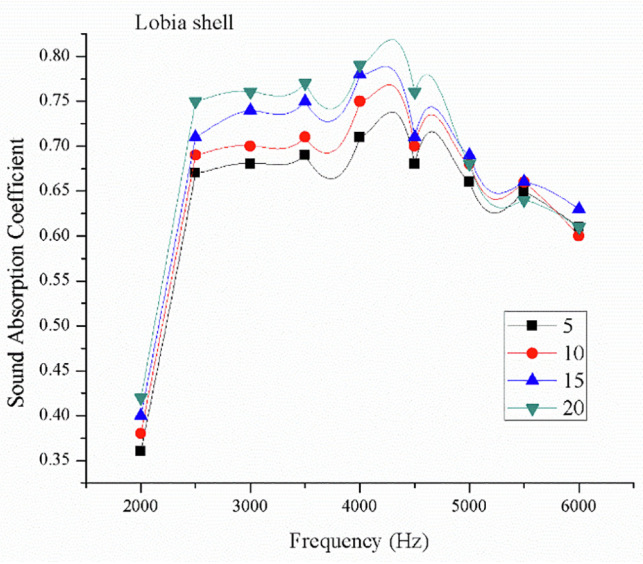

Fig. 8. Absorption coefficient of Urad dhal samples with different thickness for High frequency.

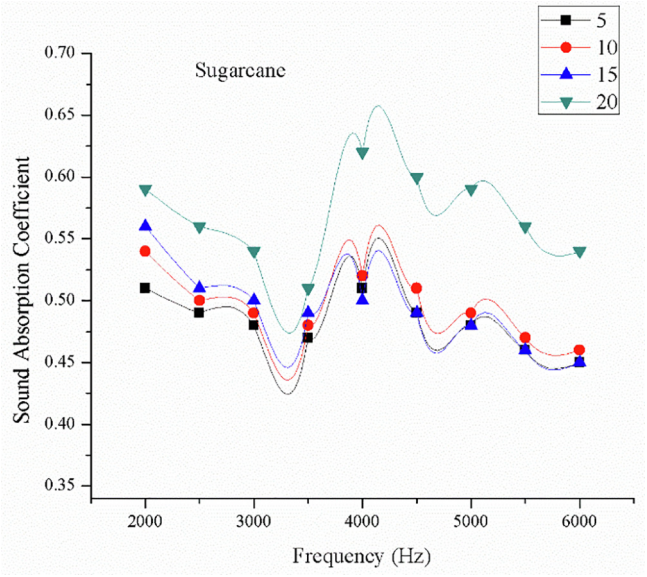

Fig. 10. Absorption coefficient of Sugarcane leaf samples with different thickness for High frequency.

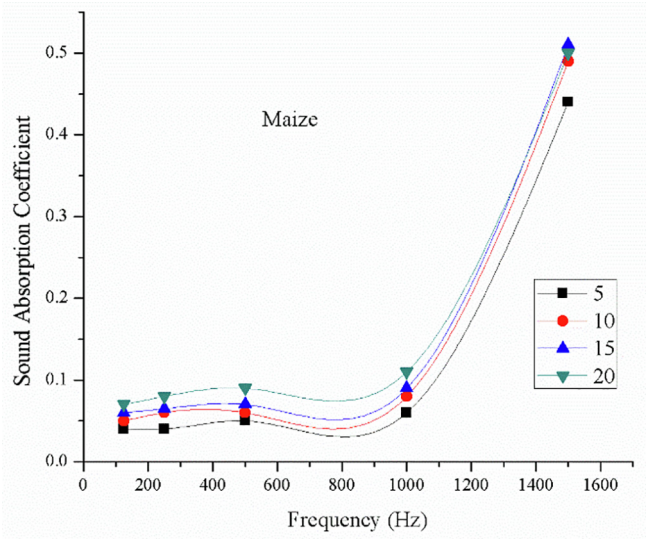

Fig. 11. Absorption coefficient of Maize samples with different thickness for Low frequency.

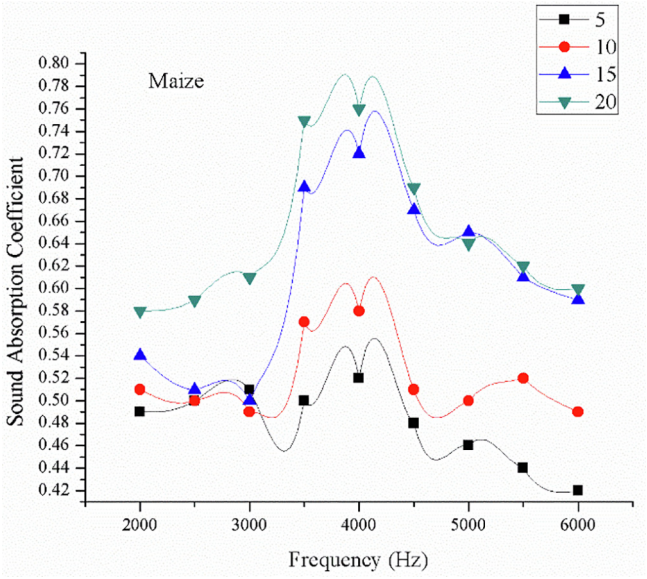

Fig. 12. Absorption coefficient of Maize samples with different thickness for High frequency.

and woven to make masks, moccasins, sleeping mats, baskets or cornhusk dolls. Corncobs is generally used for fuel, for game darts or for ceremonial use. The Figs. 11 and 12 give the sound absorption properties of panels made from maize for low and high frequency range. The sound absorption values are getting increased while the thickness of the samples were increased. The same is also observed when increasing the frequency of tests.

4. Conclusion

Five kinds of farm wastes selected for this study were lobia shell, sugarcane leaf, urad dhal shell, coconut leaf and maize. All these agri wastes are burned in the field causing environment pollution in a big way. This study tries to find the alternative way to utilize the residues as sound absorption panel so as to avoid the burning of it and environmental problem associated with it. Experimental investigations have been performed to assess the acoustic performance of farm wastes. All materials have been shown to possess good sound absorption performance in normal incidence sound absorption tests carried out using impedance tube method. The efficiency of studied material in absorbing sound showed a steady increase when increasing the thickness of the samples.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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