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This paper presents a research on the properties of new waste material reinforced composites to absorb sound. The raw materials used to prepare these composite materials are wastes generated from the textile, maize and newspaper wastes. These raw materials were bonded using Poly Vinyl Acetate (PVA) adhesives. The seven samples of different combinations and proportion were prepared with the diameter and thickness of 99.5mm, 100mm respectively. Sound absorbing capacity for these new composites relays on the nature and proportion of the waste used. The sound absorption coefficient for each sample was determined using impedance tube method. The test results indicated that, while the frequency increases then the sound absorption coefficients increases for all the samples. The maximum sound absorption coefficient (0.43) at highest frequency and extreme Noise Reduction Coefficient (0.2875) are found in the sample having 75% maize and 25% textile wastes as reinforcements. This waste material exploitation approach is more cost beneficial and offers an environmental friendly solution to the noise control.

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II. INTRODUCTION

The growing environmental awareness strategies espoused in today's world demands the industries to treat wastes as a resource that should be valorized for developing new products. In 2014, 32 million tons of textile and wood wastes and 68 million tons of paper wastes were generated which accounts around 39% of total municipal solid wastes which is generated every year in the United States [1]. In India, as per the studies conducted by Central Pollution Control Board (CPCB) New Delhi, this proportion generated varies from 3-10%, 30-45% and 1-5% of paper, wood and textile wastes respectively [2]. However, these wastes generated from the industries have been increasing gradually every year and needs to be recycled or reused. Reusing of these wastes is better than recycling process [3]. The adverse noise caused due to the advancements in mechanical tools has turned out to be predominantly more complex problem. Taking a cue from this thought, textile and maize wastes can be integrated with paper wastes to produce a sound absorbing material which would help to combat noise pollution. A major interest has been noted in the use of recyclable materials for making composite materials [4-8]. These materials have lower impact on production costs. The influence of inserting fibers plays a major role on noise control in using tea leaf fiber [9], wooden fibres [10, 11] and textile fibers (Bamboo and Jute) [12-14]. The thin (fine or hollow) fibers are preferred than the thick fibers because more fibers are necessary for same volume density which leads sound to travel in a tortuous path and a higher air flow resistance absorbs the sound waves [15-17]. So the sound absorption coefficient increases with decrease in fiber diameter [18, 19]. The porosity and airflow resistivity are the key features in absorption of sound waves [20] which requires correlation between the resin used as matrix and reinforcement material. This work focuses on the evaluation of the acoustic absorption properties of new panels made from newspaper, maize and textile wastes.

III. METHODOLOGY

3.1 Material Preparation

The textile wastes are recycled into the fiber by a sequence of methods using cutting machine, fabric opener and web former. These wastes are cleaned well as they will contain many unwanted materials like papers, sewing thread, lining pieces, broken metal parts, buttons and other contaminants. These contaminations are removed manually. The cleaned materials are cut into required sizes using cutting machine in the garment. By the fabric opener, the trimmed wastes are opened into tuft of threads. The chopped pieces of wastes are fed into the feed conveyor. The pair of feed rollers will hold the pieces to opener where they will be opened to yarn bits. When processed twice by opening and stripping action in this machine, the yarn tuft will open further to get fibrous materials. The fed web in this machine is opened further to achieve very thin layer of fiber, which is deposited over the circumference of the condensing cages (by the aerodynamic principle of web formation) and thus the thin fibrous layer is formed. A large quantity of waste such as fiber, dust, thread and chopped pieces of fabric etc., are generated during this process. They are dumped in the ground or burnt in sizing and processing industries or an open area polluting the environment. This waste is used with the recycled newspapers and maize stems which were cut into small pieces and dried.

3.2 Fabrication of Specimens

The fabrication of samples is divided into two stages, namely the pre-treatment stage and the fabrication stage as shown in Figure 1. In pre-treatment stage, the maize waste was cut into small pieces of length 5-10 cm. It was then sun-dried for one week and heated in the oven at 80° C for 5 minutes to let the excess water in the fiber evaporated. This was again cut into a length of 1-5 mm. In pre-treatment stage the newspaper was cut into pieces of length 5-10 cm, soaked in water for 24 hours, grinded and sun dried for one week. In the preparation stage, the raw materials of two different compositions were bound with PVA. It was then pressed into the mould to obtain a round shape. The pressure given was just enough for the sample to take the required shape. This was done to retain the porosity of the sample. All fabricated samples as shown in the figure 2 have a diameter of 99.5 mm to fit into the impedance tube with the thickness of 10 mm. These seven samples have different waste materials compositions based on weight percentages as shown in Table 1.

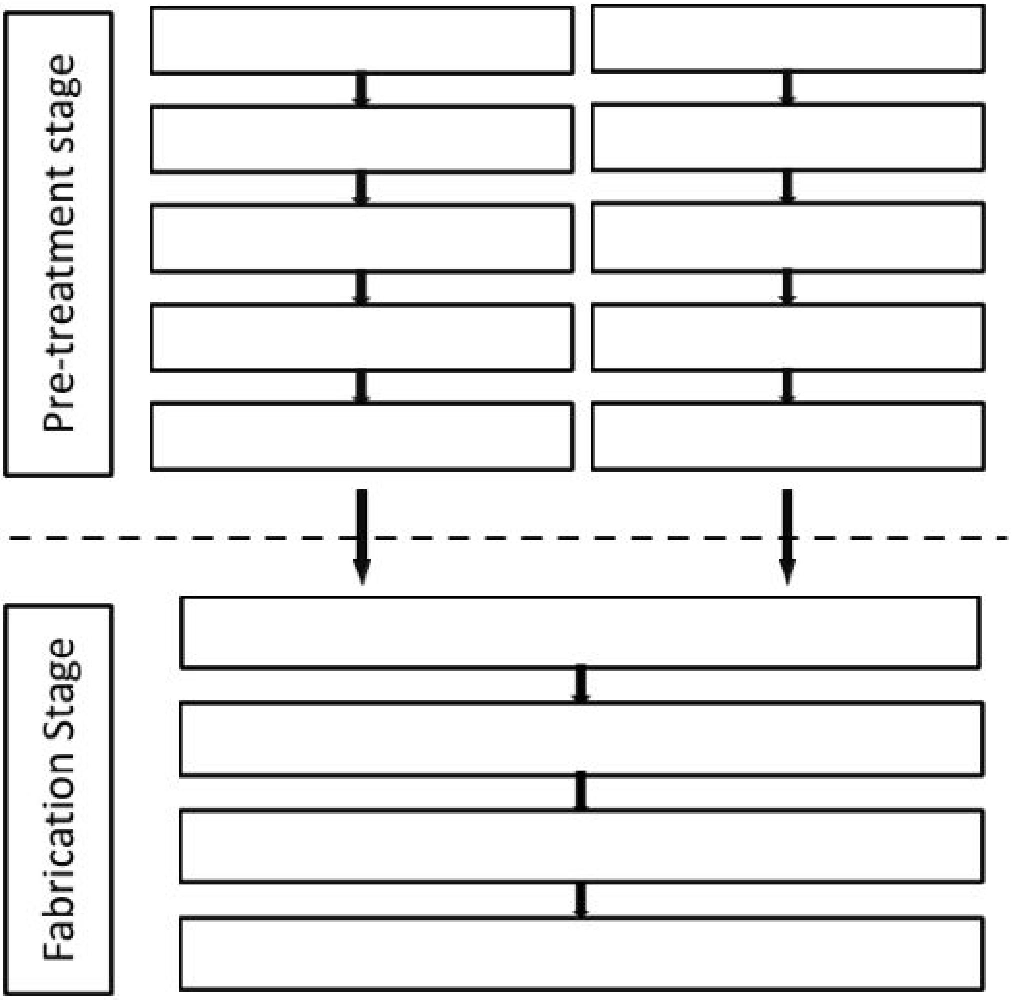

Figure 1: Steps involved in Sample preparation

Table 1: Composition of waste materials Composites

Sample	Materials (Type of waste and % by weight)
S1	25 % Newspaper + 75 % Textile waste
S2	50 % Newspaper + 50 % Textile waste
S3	75 % Newspaper + 25 % Textile waste
S4	25 % Maize waste + 75 % Textile waste
S5	50 % Maize waste + 50 % Textile waste
S6	75 % Maize waste + 25 % Textile waste
S7	100 % Textile waste

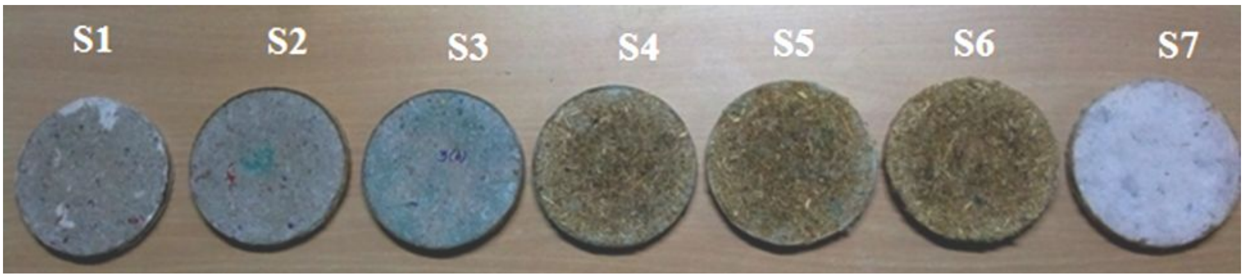

Figure 2: Waste material Composite Samples

3.3 Sound Measurement Setup

Acoustic performance of sound absorbing material was determined by the sound absorption coefficient. An impedance tube [21] as shown in figure 3 was used to determine the sound absorption coefficient of sound absorbing materials. A frequency-weighing unit is also provided within the tube for measuring high pass (high frequency measurements in the small tube), linear (measurements in the large tube), and low-pass (for additional measurement accuracy below 100 Hz) frequencies. The measurements were made on two-microphone transfer-function method as per standards ISO 10534-2 [22]. Rigid termination is available at one end for completely arresting the sound wave transmission. A Brüel & Kjaer tube kit (Type 4206-A) was used to measure sound absorption coefficient.

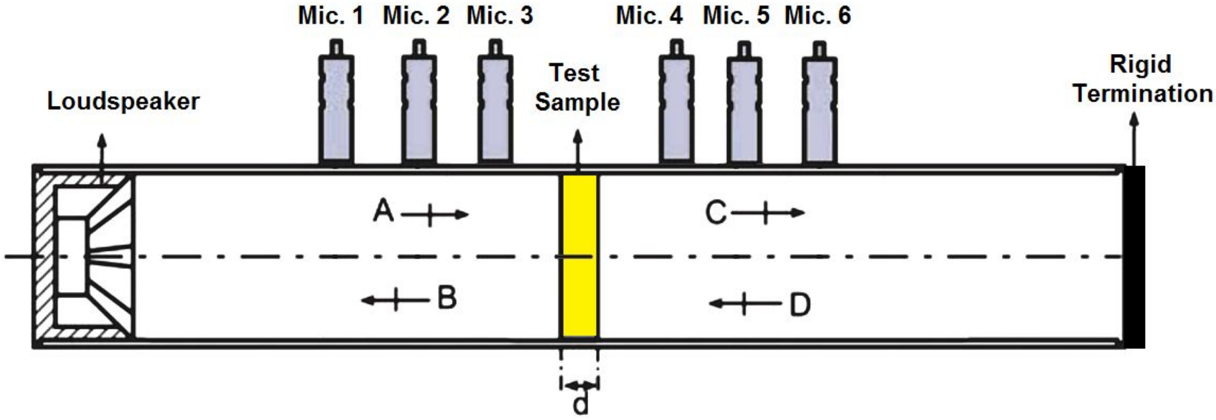

Figure 3: Schematic diagram of impedance tube for sound measurements

However, identifying the better sound absorbing materials is so tedious since there are many ups and downs in the values of sound absorption coefficients at different frequency ranges [23]. To solve this problem, the ability of material to absorb sound can be indicated using a single value known as the Noise Reduction Coefficient (NRC) [24]. The NRC is defined as the arithmetical average of the sound absorption coefficients (α) in the central frequency bands [25] such as 250, 500, 1000 and 2000 Hz which can be calculated using the following equation (1).

$$NRC = \frac{250 + 500 + 1000 + 2000}{4} \qquad (1)$$

IV. RESULTS AND DISCUSSION

For each sample, five sound absorption coefficient readings were noted and then the mean of these measured data are plotted in the Figure 4. It is observed that different waste materials have dissimilar properties with respect to the surface and inner reinforcement bonding nature. These properties influence the porosity of the samples, which in turn affects the sound absorption properties. In order to allow sound dissipation by friction, the sound waves have to enter inside the porous medium. This means, there should be enough pores on the surface of the material for the sound to pass through and get dampened. From the figure 4, it is observed that, if the paper waste reduces, the sound absorption coefficient increases. At lower frequencies unto 200Hz, the higher content of paper wastes composites increases the sound absorption coefficient up to 0.10. However, for higher frequency ranges in higher percentage of paper wastes and lower percentage of fiber (Textile waste) reduces the sound absorption property due to the higher values of flow resistivity and lower values of porosity.

When higher percentage of maize waste is mixed with textile wastes, then the sound absorption performances improves until 800 Hz and then reduces. This phenomenon is due to fact that higher maize waste cells collapses and merges into larger cells which in turn limits the sound absorption ability [26]. So at lower percentages of maize wastes along with increase in textile fiber wastes improves the open pore structure that in turn improves the sound absorption capacity as seen in sample S6. The sample S6 with 75% maize waste and 25% textile waste has peak sound absorption coefficient of 0.44, 0.43 and 0.42 at the frequency of 1000, 1250 and 2000 Hz.

When pure textile fibre wastes are used, then there is a steep drop in sound absorption coefficient due to the addition of only PVA as adhesive material which reduces the pores present inside the specimen.

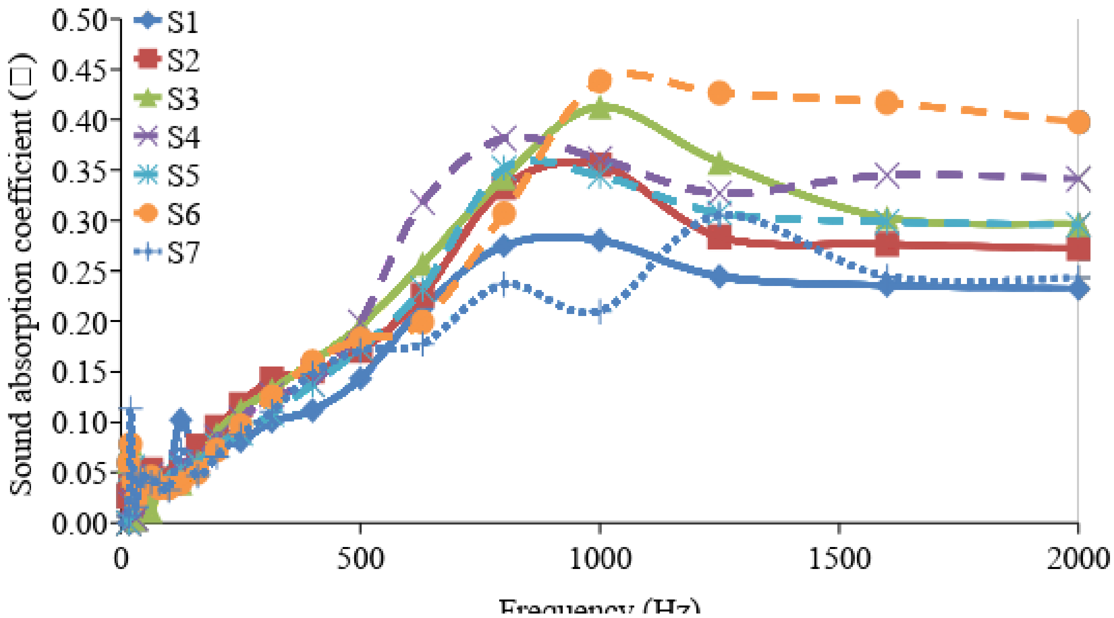

Figure 4: Sound Absorption Coefficients

The maximum value of maximum Noise Reduction Coefficient is 0.2844 for the sample S6. In addition the NRC values of all the samples are greater than the sample having pure textile fiber wastes. However there is a slight reduction in NRC value when the maize and textile wastes are equally mixed. The major cause is the reduction in interconnected voids leads to sound wave reflection rather than absorption [27].

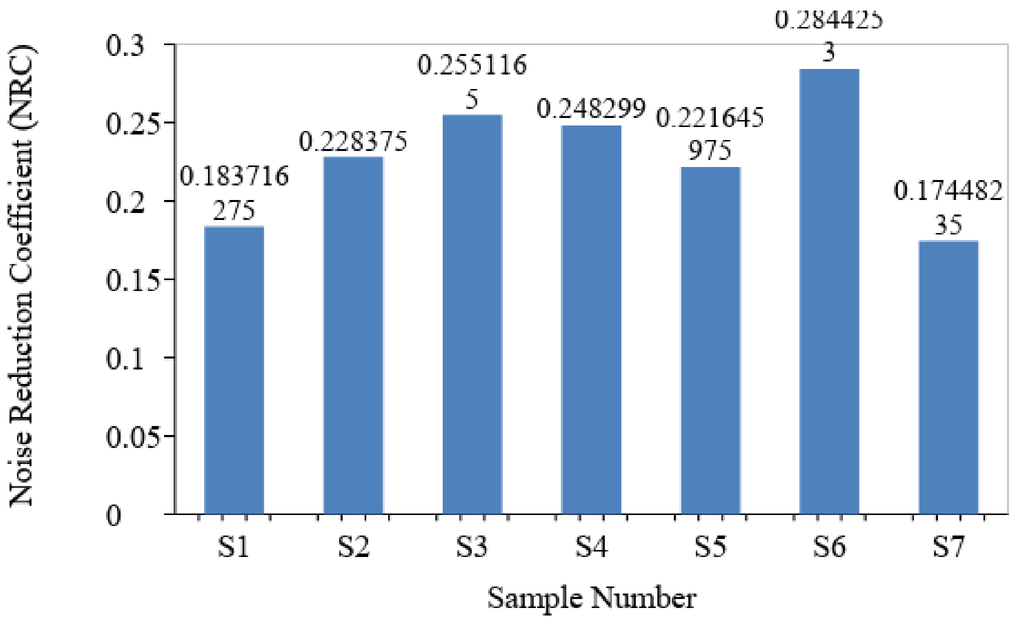

Figure 5: Noise Reduction Coefficients of samples

V. CONCLUSIONS

This research has investigated the acoustic behaviour of composite materials developed from recycled wastes which are considered to be cost beneficial and also a green building initiative. The waste materials have shown better acoustical performance especially at mixed levels than the pure levels due to improvement in the porosity. The maize and textile fiber waste combinations shows a better sound absorbing property than the newspaper and textile fiber wastes due to reduction in voids which reduces the porosity. The sample having 75 % Maize waste and 25 % Textile waste has the best capacity to absorb noise, reaching the sound absorption coefficient value of maximum 0.44 at the frequency level of 1000 Hz and the noise reduction coefficient of 0.2844. As these materials are prepared from inexpensive discarded materials from textile, farming and newspaper, the suggested approach produces a high value added ecofriendly product and helps in the pollution control.

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