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Development and Evaluation of Acoustic Sound Absorption Composite from Orange Peels Residues and Sachet Water Bags

SALEH, A

Department of Agricultural and Bio-Resources Engineering, Ahmadu Bello University, P.M.B 1044, Zaria, Nigeria

Corresponding Author: salehaminu@gmail.com; Tel: +23408 3577 4780

ABSTRACT: The goal of this study was produce a device that would reduce the unwanted sound/noise produced by machines encountered in our daily activities using orange peels (agricultural residues) and sachet water bags. These materials were prepared, mixed in 70:30 % ratio and transferred into a two-roll mill (compounding machine), where they were melted at about 150ºC temperature before transferring them to a compressing machine that was set at a lower temperature of 130ºC. The composite panel was coupled together to form a box where three speakers were connected to MP3 and inserted into the box. Test was carried out to check for the sound absorption levels of the composite using a sound level meter. Results obtained show that 'A' weighing filter covers the full frequency range of 0–90 kHz before coupling the absorption box. This could irreversibly damage the auditory system since it fell outside the acceptable range of 0–80 dB frequency sensitivity of human ear. However, the sound level becomes within the acceptable frequency when coupled to the developed absorption box indicating that the composite board using orange peels and empty water sachet is a good sound absorber.

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Noise could be defined as an unwanted sound, "disagreeable or undesired sound" or other form of disturbance which could be produced by various machines, transportation systems, engines, aircraft, doors slamming, violins, wind, and human voices etc. (Gade *et al*, 2004). From the acoustics point of view, sound and noise constitute the same phenomenon; the differentiation is greatly subjective. What is sound to one person can very well be noise to another. The recognition of noise as a serious health hazard is a development of modern times. With modern industry, the multitude of sources has accelerated noise-induced hearing loss (Hansen, 2012). While amplified music may be considered as sound (not noise) that was meant to pleasure to many people, excessive noise of much of modern industry, on the other hand, probably gives pleasure to none (Hansen, 2012). The perception of sounds as noise and the way people are affected by it depend on its physically measurable quantities such as the sound pressure level, pitch of a tone, tonality and impulsiveness. On the other hand, certain subjective factors also play a role: noise may be perceived as extremely annoying at bedtime or during activities that require a high level of concentration. All sources of noise involve movement which causes pressure fluctuations in the surrounding air (or some acoustic mediums). When pressure fluctuations reach and impinge upon the eardrum, they cause it to move, and the auditory system translates these movements into neural impulses which we experience as sound thereby causing great adverse influences on the environment, human health and economy (Gade *et al*, 2004). This necessitate the need to develop more efficient and economical ways of producing sound absorption materials in automobiles, manufacturing environments, and equipment that generate higher sound pressure drive. Particleboards are composite products typically produced from biomass (such as agricultural and municipal wastes) commonly used as material for flooring, wall bracing, ceiling boarding, furniture, partitioning, and casing (Adedeji and Ajayi, 2008). The composite material are held together by

Corresponding Author: salehaminu@gmail.com; Tel: +23408 3577 4780

synthetic resins to enhance the properties of the final composite material. Several types of resins are commonly used. However, the need to reduce the dependence on wood and forest resources has resulted in a great interest in the utilization of agricultural residues and municipal wastes for particle board production. Agricultural residues are excellent alternative materials to substitute wood because they are plentiful, widespread and easily accessible (Nialos, and Grigoriou, 2002; Xu et *al*, 2004; Ndazi *et. al*, 2007; Rahim, 2009). Several studies have been conducted on the usage of agricultural residues for the production of particle boards. These include Bekalo and Reinhardt (2010), Sekaluvu *et al.* (2014), Tayseer et al. (1999) and El Mously (1999).Disposal of orange peels has always been a problem of growing concern in urban centers in Nigeria due to its negative impact on the economy and environment. Enormous quantities of orange peels are produced annually by fruit vendors. Orange peel (rinds) as the major waste and contains 45 - 50% of the total mass of sweet orange fruits. The chemical analysis showed sweet orange peels to be rich in protein of 7.15% and crude fibre of 12.79% which can be used as ingredients in particleboard production, Oyebola *et al.* (2017). Thus, besides being a source of reducing environmental pollution and source of employment, the objective of this study was, therefore, to develop and evaluate an acoustic sound absorption Development and Evaluation of Acoustic Sound Absorption Composite from Orange Peels Residues and Sachet Water Bags.

MATERIALS AND METHODS

Materials used: The study was conducted in the Polymer Recycling Laboratory of the Nigeria Institute of Leather and Science Technology (NILEST), Samaru – Zaria using locally available materials – orange peel, polythene (sachet water bags) as resin, and 2.5 mm mesh sieve. Other materials used were: mortar and pestle, a pair of scissors (GS 68 model), Standard rectangular mould plates (Model 06AMPP0109H1), 2 roll mill compounding machines (PZ Series), compression mold machine (model HT60T), micro screw gauge (measuring capacity of 50 – 70 mm and 0.01 mm accuracy), glue (top bond), loudspeakers, and sound level meter (DB300).

Material preparation: Orange peels were obtained from Samaru market, Sabon-Gari Local Government Area - Zaria, Kaduna State. The peels were dried in oven for 24 hours at 40° C to remove free water present in it. The dried peel was grounded with a mortar and pestle, graded to obtain the peel particles of 25μm in size with a 2.5 mm diameter sieve to get fine particles. Waste pure water bags were also collected within the premises of main campus of Ahmadu Bello University, Zaria. The pure water bags were washed thoroughly to remove debris and substance that may stand as impurity, cut into small sizes with the pair of scissors and similarly dried to remove the water that was retained.

Procedure for production of particle board: The orange peels and pure water sachets were prepared in the 70:30 % ratio, respectively. After milling, the mixture of orange peels and water sachets were thoroughly mixed to obtain a homogeneous mix (Figure 1) before transferring the mixture into the compounding machine. The machine was used for compounding the samples is the 2-roll mill that functions by converting electrical energy into heat energy at a pressure of 1.23 N/mm². The temperature of the compounding machine was set to 150°C and allowed for about 30 min after which the rolls were very hot. The hot paste was removed from the roll mill and transferred into a mold of 20 cm square. Oil was used as a releasing agent on mould surface to achieve easy composites removal after formation.

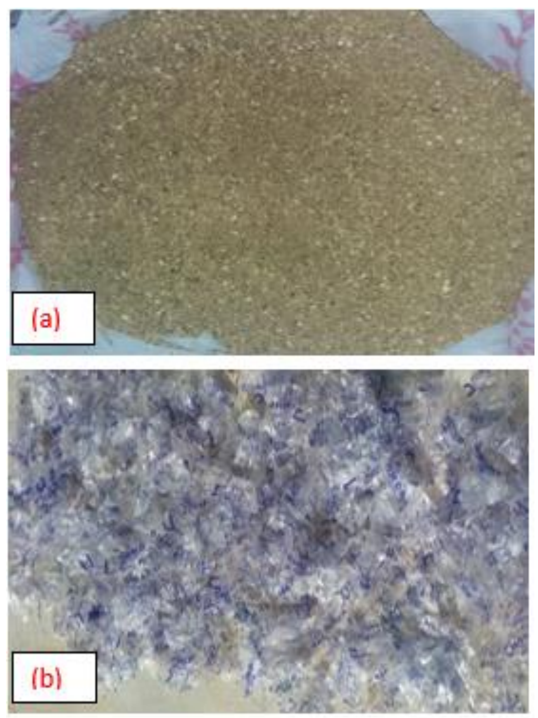

Fig 1: a) Milled Orange Peel**; b**) Empty Sachet Water Bags

A compressing machine was later set at a temperature of 130ºC and allowed for about 45 min to obtain the required temperature. The already compounded samples were then introduced to the compressing machine and allowed for 15 min before transferring it to another cold compressing machine for cooling. This procedure was repeated on the rest of the samples in order to obtain the number of particleboards required, (Figure 2).

Fig 2: Particle board

The particleboard was used to produce an acoustic absorption box. This was done by constructing a box with the composite board and top adhesive to bind the boards together and allowed to dry for about 2 hours. An adhesive (also known as glue) as non-metallic substance was applied to both surfaces of two separate particleboards that binds them together to resists separation. Three loudspeakers (Two 8 ohms, 3 watt speakers and a 16 ohms, 6 watt speaker) were connected to MP3 before putting it into the box. Sound absorption test was carried out to check for the sound absorption rate of the composite (Figure 3).

Testing of the absorption box: A digital sound level meter (DB300) was used for acoustic measurements in order to determine the acoustic quality and its suitability in a work environment as well as its compliance with noise criteria and regulations. The acoustic level meter, also called sound pressure level meter (SPL), is a commonly hand-held instrument with a microphone.

The diaphragm of the microphone responds to changes in air pressure caused by sound waves then displays the measured level on its screen. The sound level meter was set to measure: time (FAST/SLOW), frequency (“A/C”), and range (level). The microphone was then directed at the sound source to be measured (reference direction) and moved between the highest and lowest value via “MAX/MIN”. However, the basic measurement the sound level meter make is an overall dB level. This is a single number, which represents the sound energy over the entire frequency range of the meter. It provides no information about the frequency content of the sound. Information on the frequency content could be obtained by using filters.

RESULTS AND DISCUSSION

The Macro structural studies of the particle board revealed a 70 - 30% distribution of agro/municipal waste particles (orange peels) with the resin binder (water sachets). The distribution of particles is influenced by the compounding of the particle and the binder and good interfacial bonding. The sound level meter was able to record both the minimum and maximum sounds that were produced by the speakers. Similarly, the bonding glue (top bond) had firmly held the composite boards together without adding any other materials as shown in Figure 3.

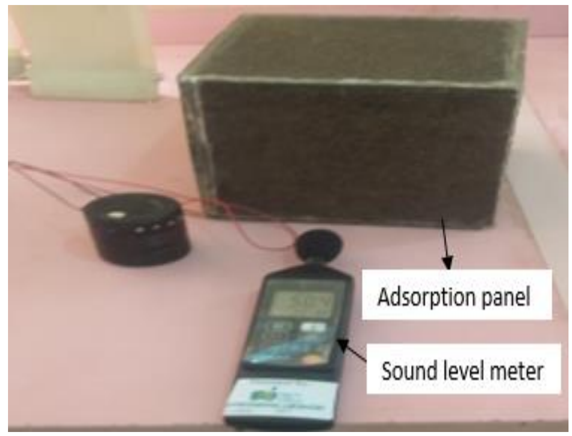

Fig 3: Assembled acoustic absorption box

Determination of sound (acoustic) absorption box properties: The properties of sound (acoustic) absorption box for both “A” and “C” Weighing Frequencies were determined. A-weighting, weights lower and higher frequencies much less, and has a slight boost in the mid-range, representing the sensitivity of normal human hearing at low (quiet) levels. C-Weighting, more sensitive to the lower frequencies, represents what humans hear when the sound is loud (near 100 dB SPL).

The use of A-weighting is mandated to be used for the protection of workers against noise-induced hearing loss. Human ears are most sensitive to frequencies between about 500 Hz and 6 kHz and less sensitive to frequencies above and below these range, Sottek (2000) and Gade *et al,* (2004).

To allow the sound level meter or noise dosimeter to measure and report noise levels that represent what we hear, Frequency Weighing’s are used, Sottek (2000) and Gade *et al,* (2004). These are electronic filters within the instrument that are used to adjust the way in which the instrument measures the noise. The most common weighing that is used in noise measurement is *A-Weighing*. Like the human ear, this instrument effectively cuts off the lower and higher frequencies that the average person cannot hear.

'A' weighing Frequency: 'A' Weighing is standard weighing of the audible frequencies designed to reflect the response of the human ear to noise. At low and high frequencies, the human ear is not very sensitive, but between 500 Hz and 6 kHz the ear is much more sensitive. From the results obtained, the 'A' weighing filter covers the full frequency range of 0 Hz to 90 kHz before coupling the absorption box. (Figure 4). This can irreversibly damage the auditory system since it fell outside the acceptable range of 0 – 80 dB frequency sensitivity of the human ear as suggested by Zhu et *al*, (2014). However, the sound level becomes within the acceptable approximates level of 80 dB frequency that does not adversely affects the sensitivity of the human ear. Thus the A-weighed value of a noise source is an approximation to how the human ear perceives the noise as suggested by Sottek (2000) and Gade *et al*, (2004).

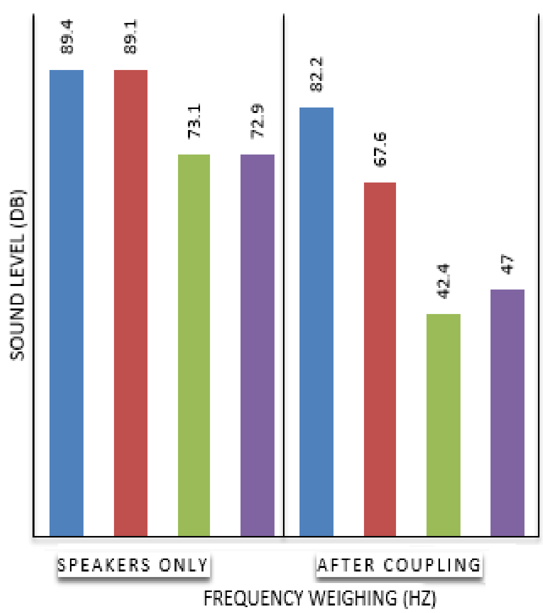

Fig 4: Properties of sound/acoustic absorption box (Frequency Weighing "A")

'C' *Weighing Frequency:* 'C' Weighing is a standard weighing of the audible frequencies commonly used for the measurement of Peak Sound Pressure level. Measurements made using 'C' weighing are usually shown with dB(C) to show that the information is 'C' weighed decibels (BS EN 61672-1:2003), Figure 2. Results obtained shows that this frequency is more suitable for low frequency sounds on human ear compared with the 'A' weighing. It thus show that C' Weighing does not discriminate against low frequencies allows uniform measurements over a wide frequency range. The absorption box is thus suitable for use in monitoring sound sources from engines and machinery.

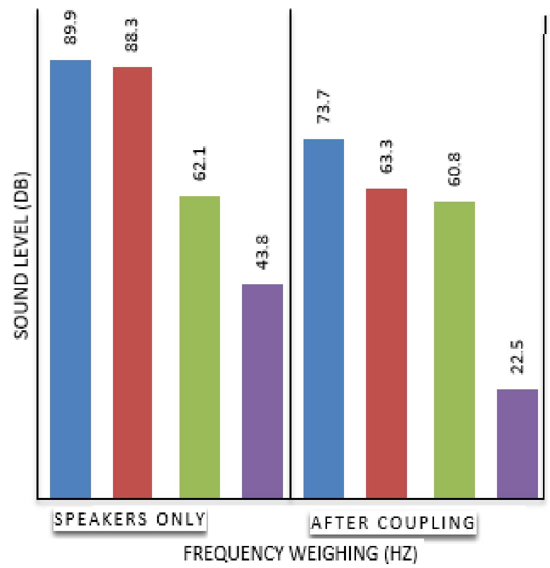

Fig 5: Properties of sound/acoustic absorption box (Frequency Weighing)

Conclusion: Orange peel and empty water sachets were used to produce an acoustic absorption particle composite. The composites was coupled to form a box which was used as a sound absorber. Three speakers were connected to MP3 player and placed inside the sound absorber box. The composite was tested using a sound level meter to ascertain its effectiveness with the objective of reducing noise produced in industries, factories and workshops. Sound level was drastically reduced after coupling the box, indicating that the composite is a good sound absorber.

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