Potential of using agricultural waste (orange peel) and empty water sachets/bags in the production of sound absorption panel

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Abstract. Noise is an unwanted sound which is mostly produced by the machines, transportation systems, engines, aircraft, etc. Noise pollution is the third pollution resource that has greatly placed an adverse effect on the environment, human health and economy. As a result, it became imperative to develop a sound absorption medium that could minimize the aforementioned effects. In this study, orange peels and sachet water bags were used to develop a composite material. The materials (i.e. orange peel and sachet water bags) were prepared into six samples (that is 280g of orange peels and 120g of sachet water bags respectively). These samples were transferred into a two-roll mill (compounding machine), where they were melted at about 150°C temperature before transferring them to a compressing machine which was already set at a temperature of 130°C. This procedure was repeated on the rest of the samples respectively. The composite panel was coupled together to form a box. Three speakers were connected to MP3 and inserted into the box. Test was carried out to check for the sound absorption of the composite using a sound level meter. Various readings were obtained which include: maximum and minimum readings at frequency weighing of “A” and “C” and the sound level drastically reduced after coupling the box, this indicates that the composite board is a good sound absorber. The reduction level of the noise should be quantified.

1. Introduction

Noise is generally an unwanted sound which could be produced by various machines, transportation systems, engines, aircraft, doors slamming, violins, wind, and human voices etc. All sources of noise involve movement which causes pressure fluctuations in the surrounding air (or some acoustic mediums). When pressure fluctuations reach the eardrum, they cause it to move, and the auditory system translates these movements into neural impulses which we experience as sound [1]. Thus, sound is produced when pressure fluctuations impinge upon the eardrum. Noise pollution has become the third pollution resource that has great adverse influences on the environment, human health and economy [1]. Noise insulation
requirements in automobiles, manufacturing environments, and equipment that generate higher sound pressure drive the need to develop more efficient and economical ways of producing sound absorption materials. Industrial applications of sound insulation, generally includes the use of materials such as glass wool, foam, mineral fibers and their composites [2].

Noise comprises all sounds which, due to their loudness and structure, are considered as harmful or annoying or stressful for human beings and the environment [1]. It depends on the condition, preferences and mood of a person whether sounds are perceived as noise or not. The perception of sounds as noise and the way in which people are affected by it depend, on physically measurable quantities such as the sound pressure level, pitch of a tone, tonality and impulsiveness [1]. Humans are particularly sensitive to noise if verbal communication is affected, e.g. if a loud conversation at the neighboring table makes it difficult for us to listen, and if we have to concentrate or want to sleep.

Sound absorbers are materials which attenuate incident sound or convert it into other forms of energy. A distinction has to be made between porous absorbers and resonance absorbers or combinations of these absorber types [3]. The key property of the sound absorber is the sound insulation of the component. Essentially, it is about the ability of components – walls, ceilings, doors, windows, etc. – to minimize the sound transmission between two rooms [3]. A high degree of sound insulation is usually achieved using solid, heavy components which hinder the propagation of sound [1].

Agricultural residues are excellent alternative materials to substitute wood because they are plentiful, widespread and easily accessible [4, 5, 6 and 7]. Aside from their abundance and renewability, utilization of the agricultural wastes could mean additional income for the farmers. Burning agricultural residue causes environmental problems such as air pollution, soil erosion, and a decrease in soil biological act [8]. Therefore, utilizing agricultural residue not only prevent air pollution due to residual burn which adversely affect air quality, human and environmental health but economically profitable for farmers [9]. Nowadays, there are several benefits in renewing biomass. However, they are mostly considered as waste materials and are as mature, ploughed into the soil or burnt on the field [10, 11]. According to the end uses of wood-waste and their possible reuse products, particle board has found typical applications as flooring, wall ceiling panels, office divider, bulletin boards, furniture and cabinet, counter tops, and desktop [11, 6]. This shows that the manufacture of particle board from recycled wood-based waste is the most common way to reuse such waste material [10, 11]. Orange peel (rinds) as the major waste, contains 45 - 50% of the total mass of sweet orange fruits. The chemical analysis showed sweet orange rinds to be rich in protein of 7.15% and crude fibre of 12.79% which can be used as ingredients in processed food. These uses will promote sustainable disposal of orange rinds [12].

Sound absorption describes the ability of materials to absorb sound or to convert the incident sound energy into other forms of energy [11]. The strength of a sound is usually given as the sound pressure level or sound level. A sound pressure level of 0 decibel (db) is the level at which human perception begins and could extend to about 140 dB [11]. Constant sound levels of more than 80 dB or very short noises of more than 120 dB can irreversibly damage the auditory system [11]. The minimum sound pressure that a human being can perceive is around 20 μPa (0.00002 Pa). This shows that human auditory system is highly sensitive to a very low pressure. Sound pressure values of 20 Pascal will damage the hearing system for very short exposure times [11].

The aim of this study was to investigate the potential utilization of orange peel in acoustic sound absorption panel as supplement and to alleviate the shortage of raw materials in forest industry. Other objectives of this study were to eradicate noise pollution produced by electrical and mechanical appliances; to find a sustainable and an eco-friendly materials to be an alternative sound absorber; to reduce deforestation and to promote effective utilization of agro-waste; and to serve as source of employment for citizen of a locality.

2. Materials and Methods

The study was conducted from purely locally available materials – orange peel (1680 g), polythene (waste sachet/water sacks) as resin (720 g), 2.5 mm mesh sieve. Resin is a chemical material that binds the fibers
together to produce particle board or medium density fiber board. Other materials used while conducting the experiment were a pair of scissors (GS 68 model), Standard Two Mold Plate (Model 06AMPP0109H1), two roll mill compounding machine (PZ Series), compression mold machine (model HT60T), micro screw gauge (measuring capacity of 50 – 70mm and 0.01 mm accuracy), glue (top bond), loudspeakers, and sound level meter (model KS SU 130).

2.1 Material Preparation

Orange peels were obtained from Samaru market in Sabon-Gari Local Government Area of Zaria, Kaduna State - Nigeria. The peels were exposed to sun light for about two weeks for proper drying to 15°C. The size of the dried material was reduced with the use of mortar and pestle, and then sieved with a sieve of 2.5 mm diameter to get fine particles. Waste pure water bags were also collected within the municipal 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 sun-dried for one week to remove the water that was in the bag (Plate 1).

![Plate 1. (a) Milled Orange Peel; (b) Empty Sachet Water Bags](image)

2.2 Assembling and Testing of the Absorption Box

Top bond was applied to each edge of the particle board and carefully coupled together, and then allowed to dry for about 2 hours. Two 8 ohms, 3 watt speakers and 16 ohms, 6 watt speakers were connected to MP3 and inserted into the box to enable effective sound. A sound level meter was used for acoustic (sound that travels through air) measurements. It was a commonly hand-held instrument with a microphone. The diaphragm of the microphone responds to changes in air pressure caused by sound waves. That was why the instrument was sometimes referred to as a Sound Pressure Level (SPL) Meter. Sound level meter requires some setting to operate; these settings include: setting the measuring time (FAST/SLOW), frequency (“A/C”), measurement range (level); then direct the microphone exactly at the sound source to be measured (reference direction) and save the highest and lowest value via “MAX/MIN”.

2.3 Procedure for Production of Particle Board

The orange peels and pure water bags were prepared into six samples i.e. 280 g of orange peels and 120 g of pure water bags respectively. Each sample was transferred into the compounding machine one after the other. The machine used for compounding the samples is the 2-roll mill. The machine functions by converting electrical energy into heat energy. 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 binder (pure water bags) was first introduced into the machine to get a molten form and then the filler (orange peel) was also introduced into the roll mills. The rolls then mix the binder with the filler to form a paste 20 minutes. The hot paste was removed from the roll mill and transferred into a mold of 20 cm square.
A compressing machine was later set at a temperature of 130°C 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, (Plate 2).

Plate 2. The Particle board

The particle board was used to produce a sound absorption box. This was done by constructing a box using the composite board using top adhesive to bind the boards together. An adhesive, also known as glue, mucilage, or paste, as non-metallic substance was applied to one surface, or both surfaces, of two separate items that binds them together to resists separation. Three loudspeakers 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.

3. Results and Discussion

The Macro structural studies of the particle board revealed a 70% - 30% distribution of agro waste particles with the resin binder. 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. The bonding glue (top bond) was able to firmly hold the composite boards together without adding any other materials as shown in plate 3.
3.1 Determination of Sound (Acoustic) Absorption Box Properties

The properties of sound (acoustic) absorption box for both Frequency Weighing “A” and Frequency Weighing “C” were determined. Human ears are most sensitive to frequencies between about 500 Hz and 6 kHz and less sensitive to frequencies above and below these range [1, 3]. 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, [1, 3]. 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’ Frequency Weighing

‘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, Figure 1.
Figure 1. Properties of sound/acoustic absorption box (Frequency Weighing “A”)

The ‘A’ weighing filter covers the full frequency range of 0 Hz to 90 kHz before coupling, Figure 1. 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 [11]. However, the sound level becomes within the acceptable approximates level of 80dB frequency that does not adversely affects the sensitivity of the human ear. So the A-weighed value of a noise source is an approximation to how the human ear perceives the noise [1, 3].

‘C’ Frequency Weighing

‘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.

![Graph showing sound level comparison before and after coupling](image)

Figure 2. Properties of sound/acoustic absorption box (Frequency Weighing)

4. Conclusion

Agricultural waste (orange peel) and empty water sachet/bags were used to produce a composite panel. They were processed with roll mill and a compression machine at the temperature of 130°C. The composite panel was coupled together to form a box which can be used as a sound absorber. Three speakers were connected to MP3 player and placed inside the sound absorber box. Tests were carried out to check for the sound absorption of the composite using a sound level meter. Various readings (maximum and minimum) at frequency weighing of “A” and “C” were obtained which include. The essence of this work was to eradicate environmental pollution due to littering of environment with agricultural waste and water sachet/bags. It was also planned to reduce the noise that is produced in industries, factories, workshop etc. From the test carried out, it was observed that the sound level drastically reduced after coupling the box, indicating that the composite is a good sound absorber.

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