THE EVALUATION OF ACOUSTIC CHARACTERISTIC PERFORMANCE ON NATURAL SOUND ABSORBING MATERIALS FROM COGON GRASS WASTE

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“In the Name of Allah, The Most Gracious, The Most Merciful”

Special Dedicate To My Beloved Mother,

You Are A Source Of Inspiration,

Thank You For All Your Sacrifices,

May Allah Bless You Always.

To My Beloved Father,

All Your Advise Would Be A Guide In My Life,

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I Wish All Of You Best Of Luck In The Future.

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ABSTRACT

In the past few decades, synthetic fibers are been used widely in the field of sound absorption due to their superior characteristics such as durable and chemical resistant. However, there are several disadvantages of synthetic fibers such as non-biodegradability and hazards to the health of human. In this research, the natural sound absorber from cogon grass was investigated. The objective of the research was to evaluate the performance of cogon grass physical characteristics on its acoustical behavior, to evaluate the effect of sodium hydroxide (NaOH) treatment times on physical and acoustical characteristics of cogon grass, to investigate the decay effects after it was left over for twelve months and lastly to compare and verify the acoustical results with theoretical models based on (Delany-Bazley and Miki Model). The measurement of acoustical characteristics which are sound absorption coefficient (SAC) and noise reduction coefficient (NRC) were done by using impedance tube method (ITM). The samples of cogon grass were tested in a way of the untreated and treated with NaOH in varied soaked hours which are one, two, three, four and five hours. Scanning electron microscope (SEM) and density kit were used to investigate physical characteristics. The research confirmed that physical characteristics of tortuosity and airflow resistivity values tend to increase with the increment of treatment times, but the density and porosity tend to decrease. Untreated samples were tested with varied thicknesses of 10, 20, 30, 40 and 50mm. The results show SAC value increases when the thickness of the sample was increased. Treated samples results show the least treated sample (1 hour) reached the maximum SAC value and indicated the highest value of NRC which is 0.50. The results also show a reduction in sound absorption value after the samples were left for twelve months. Verification parts demonstrated that Delany-Bazley and Miki Model can predict approximately pattern compared with ITM results because of the theoretical models are developed by a simple empirical model approach. Overall, cogon grass samples have the good characteristics to be an acoustic material component.

ABSTRAK

Beberapa dekad yang lalu, serat sintetik digunakan secara meluas dalam bidang penyerapan bunyi disebabkan oleh ciri unggulnya seperti tahan lama dan tahan kimia. Walaubagaimanapun, terdapat kelemahan gentian sintetik seperti non-biodegradibiliti dan memberi bahaya kepada kesihatan manusia. Dalam kajian ini, penyerap bunyi semula jadi daripada lalang telah disiasat. Objektif penyelidikan ini adalah menilai prestasi ciri fizikal lalang pada sifat akustik, untuk menilai kesan rawatan natrium hidroksida (NaOH) terhadap lalang pada ciri fizikal dan akustik, untuk menyiasat kesan kerosakan selepas dua belas bulan terbiar dan terakhir untuk membandingkan dan mengesahkan hasil akustik dengan model teori (Delany-Bazley dan Miki Model). Pengukuran ciri akustik seperti pekali penyerapan bunyi (SAC) dan pekali pengurangan bunyi (NRC) dilakukan dengan menggunakan kaedah tiub impedans (ITM). Sampel lalang diuji dengan cara tidak dirawat dan dirawat dengan NaOH dalam rendaman jam yang berbeza iaitu 1, 2, 3, 4 dan 5 jam. Pengimbasan mikroskop elektron (SEM) dan kit ketumpatan digunakan untuk menyiasat ciri fizikal. Penyelidikan mengesahkan bahawa nilai ciri fizikal untuk kedalaman liang dan kerintangan aliran udara meningkat selari dengan peningkatan masa rawatan, tetapi kepadatan dan keliangan cenderung untuk menurun. Sampel yang tidak dirawat telah diuji dengan ketebalan berbeza iaitu 10, 20, 30, 40 dan 50 mm. Keputusannya, nilai SAC meningkat apabila ketebalan sampel meningkat. Keputusan sampel yang dirawat menunjukkan, rawatan jam paling kurang (1 jam) mencapai nilai maksimum SAC dan memperolehi nilai tertinggi NRC iaitu 0.50. Keputusan juga menunjukkan nilai penyerapan bunyi berkurangan selepas ditinggalkan selama dua belas bulan. Bahagian pengesahan menunjukkan bahawa Delany-Bazley dan Model Miki meramalkan corak hampir sama dengan keputusan ITM kerana model teori dikembangkan dengan pendekatan model empirikal yang mudah. Secara keseluruhan, sampel lalang masih mempunyai ciri yang baik untuk menjadi komponen bahan akustik.

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LIST OF SYMBOLS

f	-	Frequency
λ	-	Wavelength
v	-	Velocity of sound
f_0	-	Resonance frequency
c	-	Speed of sound
s	-	Neck opening area
v	-	Volume of the void
I	-	Depth of neck
b	-	Radius of neck opening
m	-	Mass by surface
d	-	Displacement between membrane and rigid wall
t	-	Thickness
ρ	-	Density
Φ	-	Porosity
α_∞	-	Tortuosity
σ	-	Airflow resistivity
v_0	-	Volume of the void space
v_T	-	Total volume of the porous material
R_s	-	Electrical resistance of the porous material impregnated with the conducting fluid
R_f	-	Electrical resistance of the conducting fluid is measured alone
ΔP	-	Pressure drop when across the sample
U	-	Volume flow

d	-	Sample thickness
M	-	Mass of the piston
g	-	Acceleration via gravity
A_p	-	Cross-sectional area of the piston
S_s	-	Cross-sectional area of the samples
v	-	Terminal velocity of the piston
Λ	-	Viscous characteristic length
s	-	Constant value of scattering coefficient
η	-	Viscosity of air
r	-	Diameter of fiber
l	-	Length of fiber
Pa	-	Pascal
Λ'	-	Thermal characteristic length
V_p	-	Volume of the pores
S_p	-	Surface of the area
α	-	Sound absorption coefficient
I_a	-	Sound intensity absorbed
I_i	-	Incident sound energy
γ	-	Wave propagation number
Z_c	-	Characteristic acoustic impedance
R	-	The real component
X	-	The imaginary component
α	-	Attenuation constant
β	-	Phase constant
ω	-	Angular frequency
ρ_0	-	Density describes value in the air
c_0	-	Speed of air in the air
N_p	-	Fluid Prandtl number
δ_v	-	Viscous boundary layer thickness
δ_h	-	Thermal boundary layer thickness
C_p	-	Specific heat capacity of air at constant pressure
κ	-	Thermal conductivity of air

W_s	-	Saturated sample weight
W_d	-	Dry sample weight
W_i	-	Saturated immersed sample weight
ρ_s	-	Density of saturating liquid

LIST OF ABBREVIATIONS

dB	-	Decibel
i.e.	-	For Example
Hz	-	Hertz
WCED	-	World Commission on Environment and Development
NaOH	-	Sodium hydroxide
SEM	-	Scanning electron microscope
WHO	-	World Health Organization
OSHA	-	Occupational Safety and Health Administration
PU	-	Polyurethane
PVA	-	Polyvinyl Acrylic
NRC	-	Noise reduction coefficient
SAC	-	Sound absorption absorption
STL	-	Sound transmission loss
STC	-	Sound transmission class
Sdn.	-	Sendirian
Bhd.	-	Berhad
PPE	-	Personal protective equipment
ITM	-	Impedance tube method
UTHM	-	Universiti Tun Hussein Onn Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Noise is derived from the Latin word "nausea" implying 'unwanted sound' or 'sound that is loud, unpleasant or unexpected'. The noise originates from human activities, especially the urbanization and development of transports and industries. Though, the urban population is much more affected by such pollution, however, small towns or villages along side roads or industries are also victims of this problem. Noise is becoming an increasingly omnipresent, yet unnoticed form of pollution even in developed countries. According to the recent study, road traffic, jet planes, garbage trucks, construction equipment, manufacturing processes and lawn mowers are some of the major sources of these unwanted sounds that are routinely broadcasted into the air (Birgitta & Lindvall, 1995).

Sources of noise pollution include inter alia, vehicular traffic, neighborhood, electrical appliances, television and music system, public address systems, railway and air traffic, and generating sets. Most of the people inhabiting metropolitan cities or big towns and those working in factories are susceptible to the adverse effects of noise. Characteristically, it affects the rich and the poor alike. The problem of noise pollution is less in small towns and villages. But, those residing in villages or towns along the national or state highways or close to railway tracks do bear the brunt of excessive noise. It may cause deafness, nervous breakdown, mental disorder, heart troubles and high blood pressure, head-aches, dizziness, inefficiency and insomnia (Bhargawa, 2001).

In the last 40 to 50 years, the use and variety of available specialized sound absorbing materials has increased greatly. Use of synthetic fibers and fibrous acoustic materials is still frequently found especially in building acoustics as well as in noise control applications because of their high performance at mid-high frequency range. The common acoustical panels that are made from synthetic fibers are known for their toxicity and polluting effects which are harmful to human health as well as to the environment. Synthetic fibers made from minerals and polymers are used mostly for sound absorption and thermal isolation. The products such as glass and rock wool made from minerals have been presented that their production can release more carbon dioxide into the atmosphere compared to those made from natural materials (Asdrubali, 2006).

In the 1970s, a series of events related to public health concerns made makers of sound-absorbing materials change the main constituents of their products from synthetic fibers to the natural or green fiber technology. The use of natural fibers in manufacturing sound absorbing materials has received much attention (Ballagh, 1996). Natural fibers are chosen to be alternative materials because they have very low toxicity which is good to protect the environment (D'Alessandro & Pispola, 2005). Natural fibers are essentially completely biodegradable and modern technical developments have made natural fibers processing more economical and environmentally friendly. These new methods may result in increased use of high quality fibers at competitive prices for industrial purposes. The absorption properties of sound-absorbing materials made of these fibers can be similar to those made from minerals. In addition, natural fibers are also safer for human health compared with most mineral synthetic fibers, since they do not need precautions in handling.

For over past century, porous absorbers are the most common material used as a sound absorption. Therefore, porous materials have been found to be very useful for the control of noise because they absorb most of the sound energy striking them and reflect very little. Common porous absorbers include carpets, aerated plaster, mineral wool, textiles, clothing, curtains, and certain types of foam plastic, fall into this category. They are used in a variety of locations such as the place which produce an unpleasant sound, roaring sound in the room, in other words a lack of acoustic comfort.

1.2 Problems Statement

At present, noise pollution is a slow and subtle killer, yet very little efforts have been made to ameliorate the same. It is, along with other types of pollution has become a hazard to quality of life. Relatively low levels of noise affect human health adversely (Kiernan, 1997). It may cause hypertension, disrupt sleep and or hinder cognitive development in children. The effects of excessive noise could be so severe that either there is a permanent loss of memory or psychiatric disorder (Bond, 1996). Thus, there are many adverse effects of excessive noise or sudden exposure to noise. The main characteristic of a sound absorbing material is its ability to absorb most of the sound energy that strike them, hence making them very useful for the control of noise (Crocker & Arenas, 2007). Although a wide range of synthetic sound-absorbing materials exist, recent issues on human health and negative effects of pollutions have increased the public awareness and push forward the demand for environmental friendly materials, less contaminating processes and recycled products (Arenas & Crocker, 2010). On other scenario, generation of solid waste from agricultural activities has caused several problems on-site such as disposal issues, hazards to workers as well as becoming a breeding ground for vermin and other pests carrying diseases (Reddy & Yang, 2005).

In order to support green environment campaign, acoustic absorbers from natural materials are used due to their biodegradability and sustainability. Sustainable is now seen to be pervasive (Lubben & Pitt, 2009). In 1987, World Commission on Environment and Development (WCED) defined the definition of sustainable; also known as the Brundtland Report, stated that "*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987). However, most of the natural fibers are left abandoned all over the world such as cogon grass. Cogon grass (*Imperata Cylindrica*) has become a major problem for landowners, land managers and foresters. Cogon grass is considered as one of the world's worst weeds. Known to many as "Jap grass", cogon grass was accidentally introduced into Alabama near Grand Bay about 1911 as seed in packing materials from Japan (Dickens, 1974). Seed of cogon grass is variable and seed must land on bare ground for germination (Dickens, 1973). Rhizomes of cogon grass are white, segmented, branched and have been found extending 48 inches below the soil surface. It can extend about 10 feet yearly from an established plant (Yager, Miller & Jones, 2005). Cogon grass is opportunistic and invades a wide range of non-cultivated habitats including forests, pastures, orchards and waste areas. The weed is commonly known as a pest especially to farmers because crops are disturbed by the weed. As these wastes cannot be used as food, cogon grass usually is burned in order to clear the field for the next crop. Cogon grass is a fire adapted species, meaning that it thrives where fire is a regular occurrence (Bryson & Carter, 1993). In other parts of the world, such as Southeast Asia, cogon grass has been very beneficial. The weed has numerous uses, from edible to medicinal uses. The roots are tough to chew but contain starch and sugar. The ash of this plant can be used as a salt substitute. Some medicinal uses include if you have a painful outgrowth at the tongue. In Philippines, cogon grass has been used primarily for crafts such as baskets, bags like purses and a wide variety of decorative purposes.

Regarding to the environmental concerns, the aim of this research is to determine the performance of the natural fibers material which is cogon grass, in terms of sound absorption coefficient, in becoming alternative sound absorbing materials. Even so many benefits of natural fibers, there are still drawbacks or problems related with these natural fibers. Untreated natural fibers are not so good at high temperature and leads to poor interface between the fibers matrix. To make natural fibers as a good option to be as an absorber, it is required that the natural fibers undergo the process of treatments in order to improve the compatibility between the matrix and the fibers (Bella, Fiore & Valenza, 2010). Most of the treatments used on natural fibers are using sodium hydroxide (NaOH). This treatment removes the wax, lignin and oil covering the natural fibers that lead to a better interlocking matrix and fibers (Manalo *et al*., 2015). Other problem of natural fibers is they do not possess a long-lasting characteristic. It still needs a treatment with NaOH to cope the problem. The treatment gives resistance to the natural fibers against fungal decay (Xie *et al.*, 2010). Along the number of problems, cogon grass is still one of good natural fibers to replace synthetic fibers such as glass wool, rock wool and asbestos.

1.3 Objectives

The objectives of the study are:

i. To evaluate the performance of physical characteristics on the acoustical behavior of cogon grass.
ii. To evaluate the effect of NaOH treatment time on physical and acoustical characteristics of cogon grass.
iii. To investigate the effect of decay on acoustical characteristics.
iv. To verify the acoustical characteristics obtained experimentally with the theoretical model.

1.4 Scopes

The study of sound is a broad field. The basic principle of the acoustic field must be understood preferably before the start of the study. This understanding can be obtained through reading materials related to sound. The scopes of this study are:

i. The sample will be made of cogon grass fibers or its scientific name is *Imperata Cylindrica.*
ii. Cogon grass fibers will undergo treatment with and without sodium hydroxide (NaOH).
iii. Cogon grass fibers will be soaked with 6 % of NaOH at varied times soaked for 1, 2, 3, 4 and 5 hours.
iv. Physical properties such as density, porosity, tortuosity, airflow resistivity and thickness will be tested on cogon grass fibers.
v. Acoustical properties such as sound absorption coefficient and noise reduction coefficient will be determined after physical properties testing in laboratory.
vi. Decay test were performed to investigate whether it still can make a good absorption or not after cogon grass was left over for a twelve months.

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