MICROSTRUCTURED COCONUT SPATHE FIBERS AS BIOFILTER MEDIA FOR AIRPOLLUTION CONTROL

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ABSTRACT

Air pollution posed a public concern to communities in a global scale. Hence, this study explored the potential of coconut spathe fibers as air filter media in order to reduce pollution level. Coconut spathe fibers (CSF) were cleaned and cut to 7cm by 7cm of thickness 0.5cm. Air filters were made up of the coconut pouch sandwiched between two metal plates. Metal plates were ridden with evenly distributed 1cm diameter holes and 1cm apart. Filters were constructed in triplicates and tested against air pollution. The free-acceleration test for in-use compression-ignition motor vehicles based on European Emission Standards pursuant to Section 21 of Republic Act 8749 (Philippine Clean Air Act of 1999) was employed. Smoke Opacity Measurement (SOM) was done to the assess air quality before and after filtration as a function of thickness using the free acceleration principle. Light- absorption coefficient (κ) of the exhaust gases was measured with a digital opacimeter. Three replications were done. Mean values were reported and statistically analyzed using SPSS software. Test was performed to quantify the amount of air pollutants that impair visibility, including aerosols and particulate matters, in the gaseous exhaust.. Results suggest that car exhaust smoke after passing through CSF filters became relatively transparent light. This study illustrates the potential of coconut spathe fibers as an alternative natural air filter system for air pollution control.

Keywords: air filters, air pollution, spathe fibre, opacity coconut

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1. INTRODUCTION

It is well documented that exposure to air pollution causes adverse health effects such as asthma in children and adults, chronic obstructive pulmonary disease in the elderly, lung infections, and cardiovascular morbidity (Muala et al., 2014; Chuanfang, 2012). In fact, the diesel exhaust has been shown to be a predominant contributor to urban fine particulate matter air pollution, estimated by the World Health Organization (WHO) to result in 3.2 million deaths annually worldwide (Muala et al., 2014). Hence, there is an urgent need to consider and evaluate methods to reduce individual exposure.

At present, air filtering medium used to remove aerosols or airborne particles have considerably evolved through multiples scientific research focused on developing new materials for environment and equipment protection (Chuanfang, 2012; Otani et al, 2007; Kezrane, n.d.). In fact, air filters based on synthetic substances dominate the market for their technical and economic advantages such as ease of implementation and of low cost (Kezrane, n.d.). However, synthetic fibers may pose a source of pollution and health risks (Kezrane, n.d.). Because of the increasing need to protect human health and to create a cleaner world, aerosol filtration is becoming more important. Hence, there is a need to look for a low-cost and eco-friendly air filters. Among various ways to detoxify polluted air is by biological processes such as peat moss and sand filters. However, all of these systems are bulky, cumbersome, easily contaminated, and highly inefficient. Another alternative is filtration using fibrous media that is relatively inexpensive, simple to implement, and yet provides one of the most efficient means for collecting submicron particles (Chuanfang, 2012; Lee and Liu, 1981). To date, only few studies using fibers for air filtration were explored such as from Luffa cynlindrica. Continuous efforts were done to investigate natural fibrous substances for air filtering system.

In this study, the feasibility of using coconut spathe fibers as fibrous air filter media was investigated. The potential of coconut spathe was considered due to the fact that the coconut industry is a dominant sector of Philippine agriculture. According to Philippine Coconut Authority of the Department of Agriculture (2015), about 3.1M hectare out of the 12million hectare is devoted to coconut and 68 out of 79 provinces are coconut areas.

The main objective of this work was to determine if the coconut spathe fibers are also effective as filtering media to control air pollution. Specifically, it also aims : (i.) to determine and compare the level of pollutants in terms of light absorption coefficient (κ) with and without the spathe based filtering media, (ii) to measure and compare the level of

pollutants in termsof light absorption coefficient (κ) as a function of spathe based filtering media layers.

2. MATERIALS AND METHODS

2.1. Collection of Spathe Coconut Fibers as Air Filter Media

Spathe fibers form coconut tree as depicted in Figure 1 were collected, washed with water, air-dried, and stored in a desiccator until further use. Spathe fibers were formed into a rectangular shape having a dimension of 7cm x 7cm x 1cm. Air filter media was sandwiched between two metal plates, ridden with holes approximately 1cm in diameter evenly distributed about apart from each other as illustrated in Figure 2.

Figure 1: The Coconut tree sample with spathe fibers

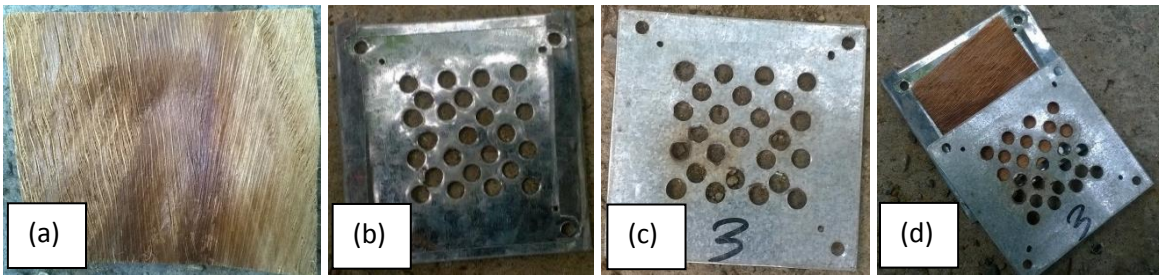

Figure 2: Improvised Filter Media. (a) spathe fibers, (b)metal plate-front view, (c)metal plate- back view, (d) filter media

2.2. Construction of Air-Filter Case Prototype

The air filter case was created by using tin to fashion an extensive chamber-like device with specifications as illustrated in Figure 3. A 7cm by 7cm computer fan with specification of 12V, 0.5A was placed near the opening of the device in order to for a forced draft to occur in order to aid in the circulation of exhaust air and particles. An adapter was also installed with specifications of turning AC household connections of 220V into 12V.

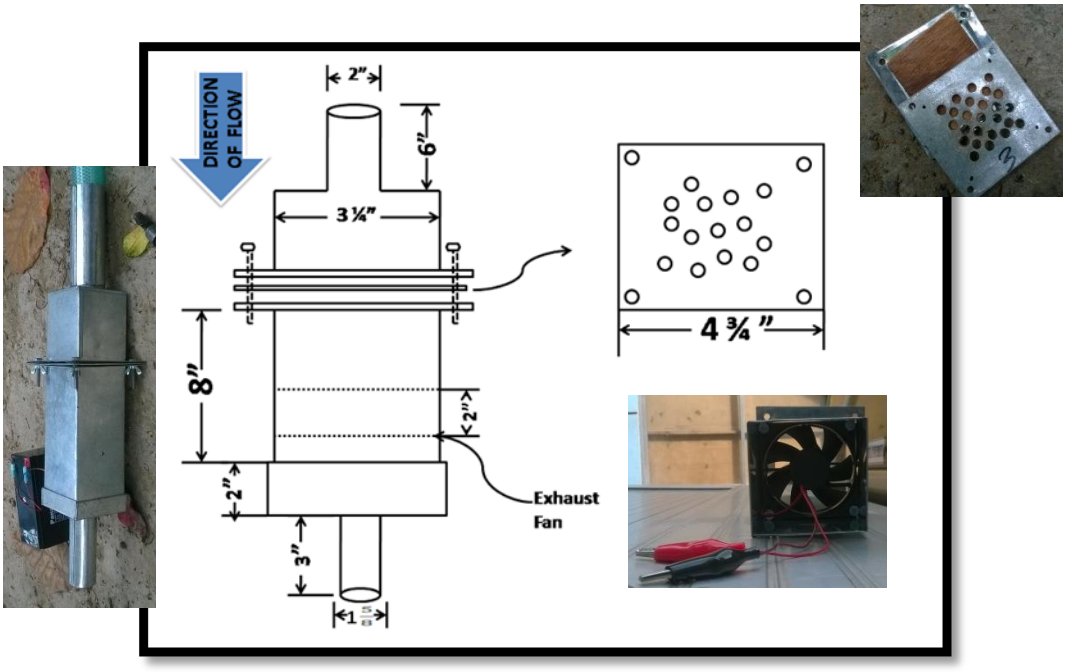

Figure 3: Air filter case prototype

2.3. Air Pollution Control Device Testing and Data Analysis

The standard smoke opacity measurement for in use motor vehicles equipped with compression-ignition (diesel) engines was conducted using the free acceleration test from low idle speed method. The light absorption coefficient (κ) of the exhaust gases with and without the spathe coconut fibers was measured with an opacimeter. The guidelines for revised emission standards pursuant to Section 21 of Republic Act 8749, otherwise known as the "Philippine Clean Air Act of 1999", were strictly followed (refer to Appendix G). Opacity sensor is used to detect and measure the amount of light blocked in smoke emitted by diesel engines.

In this study, a used 2710kg -NISSAN FRONTIER NAVARA vehicle was tested as shown in Figure 4. Experiment was done at the Department of Transportation and Communications, Land Transportaion Office (LTO) in Cebu City, Division Office under direct supervision of LTO personnel. Assessment of air quality was reported in terms of κ

value. Three replications were done. Mean value and standard deviation were computed and statistically analyzed using and SPSS software.

Figure 4: Standard Opacity Test using a Digital Opacimeter at Land Transportation Office- Region VII

3. RESULT AND DISCUSSIONS

The light absorption coefficient (κ) of the exhaust gases from NISSAN FRONTIER NAVARA, in-use motor vehicles equipped with compression ignition (diesel) engines, before and after passing through coconut spathe layers was shown in Figure 5. Light absorption coefficient or also known as "smoke density" is a fundamental means of quantifying the ability of the smoke plumes and smoke containing gas samples to obscure light.

Results revealed that light absorption coefficient (κ) without Coconut Spathe Fibers (CSF) decreases linearly after the insertion of CSF from single to triple layers with high degree of correlation. A large value of κ before filtration, i.e. the Layer 0, means that the light beam is quickly weakened as it passes through the exhaust gases from NISSAN FRONTIER NAVARA. It also implies that the exhaust smoke was possibly composed with large amount

of suspended particulate matters and other hazardous gaseous pollutants that impair air visibility. A small value of κ after means that exhaust smoke after passing through layers of CSF became relatively transparent (clear smoke) to the light beam. It implies that the smoke became cleaner as CSF increases from single to three layers. Results demonstrate that using coconut spathe-based air filter media can substantially and rapidly reduce exposure to air pollution emitted by diesel engines. In fact, the use fibrous filters using other natural medium such as Luffa sponge and Abaca fibers were also reported by some researchers (Otani et al., 2007; Lee and Liu, 1981).

In this work, the use of inexpensive, abundant, and biodegradable filter media from coconut spathe fibers were shown to reduce concentrations of particulate matters and other harmful gaseous pollutants. Development and application of this technology could lead to significant reductions in air pollution exposure reducing possible health risks and of providing solutions for creating a clean environment.

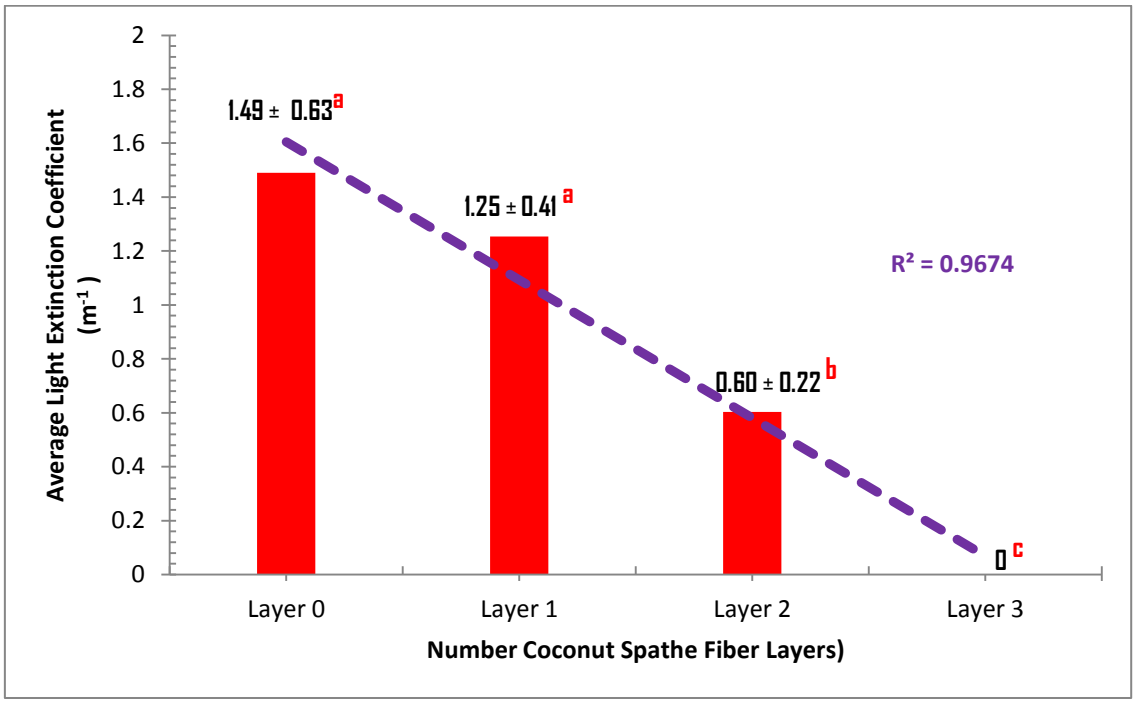

Figure 5: Light Absoprtion Coefficient as a function of Coconut Spathe Fibers

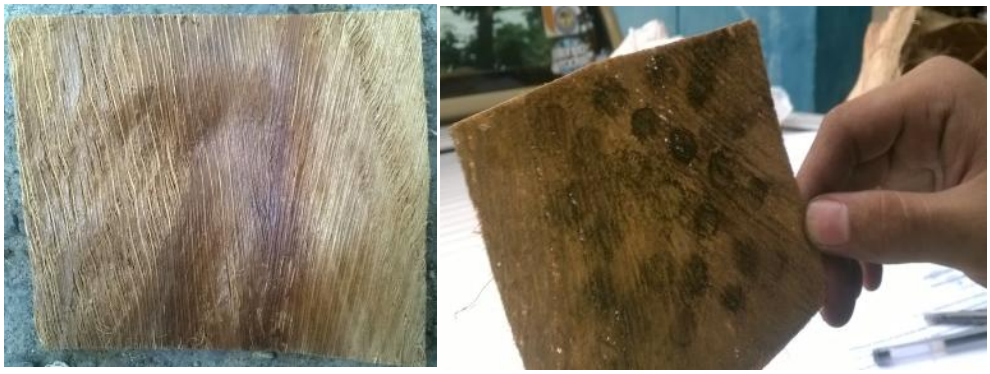

Figure 6: Physical appearance of coconut spathe fibers. before air filtration, (b) after air filtration

The ability of coconut spathe fibers in aerosol filtration could be explain through the porous structure of the said material wherein particles are captured as gas follows path created by the series of interconnected void spaces formed by the microstructure. Each time the gas streams flows through the porous opening, particles have an opportunity to deposit onto the fiber. Particles can be captured through the four primary mechanisms depicted in Figure 7 namely the diffusion, interception, inertial impaction, and electrostatic interaction (Chuanfang, 2012; Graham et al., 2002; Lee & Liu, 1981). Particle deposition via diffusion occurs when particle collide with the fiber due to their random Brownian motion. A particle is deposited via interception mechanism if a particle of finite size brought within one particle radius of the fiber as it follows the flow streamline around the fiber. Impaction occurs when a particle travelling in the air stream and passing around a fiber, deviates from the air stream (due to particle inertia) and collides with a fiber. . Electrostatic attraction plays a very minor role in mechanical filtration. After fiber contact is made, smaller particles are retained on the fibers by a weak electrostatic force.

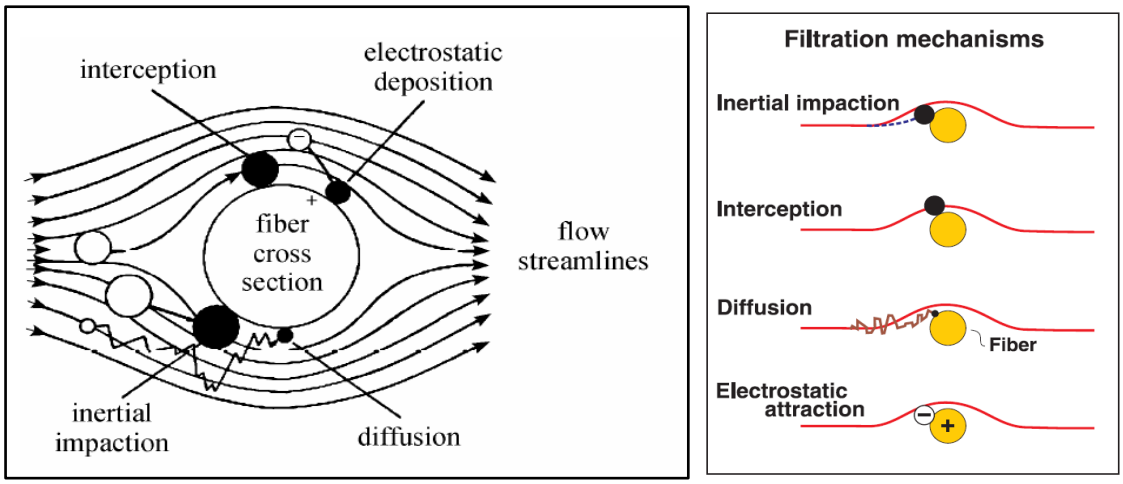

Figure 7: Four primary filter collection mechanisms using fibrous substances (Chuanfang, 2012)

4. CONCLUSION

The potential of coconut spathe fibers (CSF) as biofilter against air pollution emitted by diesel engine was successful tested. Results suggest that using CSF-based air filter media can substantially and rapidly reduce the amount of suspended particulate matters and other hazardous gaseous pollutants in the exhausted smoke. In addition, the smoke became cleaner and transparent as CSF increases from single to three layers. In addition, data revealed that the fabricated filters could produce clean and transparent air as a function of layers.This study illustrates the potential of coconut spathe fibers as inexpensive, relatively abundant, and biodegradable air filter system for air pollution control. Development and application of this technology could lead to significant reductions in air pollution exposure reducing possible health risks and of providing solutions for creating a clean environment.

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