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Project Lingap Langhap: Low-Cost 3D Printed Air Purifier System using Agricultural Waste-based Activated Carbon Filter

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Abstract. **According to the 2018 data of the World Health Organization (WHO), air pollution is responsible for seven million premature deaths each year.**
Activated carbon is frequently chosen as the medium to filter out gases and air pollutants emitted by motor vehicles and combustion processes. The agricultural waste to be used as source material for the device's activated carbon will primarily consist of rice husks, coconut husks, sawdust, and other common agricultural byproducts. The process of generating activated carbon can also facilitate many other types of organic matter to be used as source material.
The 3D design of the prototype for 3D printing was modular to accommodate upgrades or add-ons such as reusable silica desiccants and aromatic beads for moisture absorption and fragrance respectively.

Keywords: Air purifier; 3d printing; additive manufacturing; activated carbon.

INTRODUCTION

Air pollution is the presence of suspended chemicals that are detrimental to human health in the atmosphere. These particles are produced in various human activities such as fuel combustion, energy generation, and even household cooking. These chemicals are otherwise called pollutants. Recent studies also revealed that diseases persist even in people residing within areas with relatively low amounts of air pollution or with levels below the present regulatory guidelines
(Zhang et al., 2019).

The Philippines has the third highest recorded deaths due to air pollution with 45.3 deaths for every 100,000 people, thus making adverse air quality one of the biggest crises in the country (WHO, 2018).

Exhaust from motorized vehicles and other enginery produce carbon monoxide, a component of photochemical smog. Breathing in carbon monoxide can impair the ability of the body to circulate oxygen, a necessity for all bodily organs. Nitrogen dioxide, another gas found in smog, can exacerbate asthma and bronchitis, which may develop into a respiratory infection. Nitrogen dioxide is often generated from energy and industrial generation (Ambag, 2019).

Natural ventilation through the use of windows or doors has been the easiest and most effective method to improve indoor air quality (IAQ), where people spend over 80% of their time (Oh et al., 2014). However, high PM 2.5 concentrations in the outside air make using this method challenging. As a result, a market for air purifiers used to improve IAQ is expanding rapidly.

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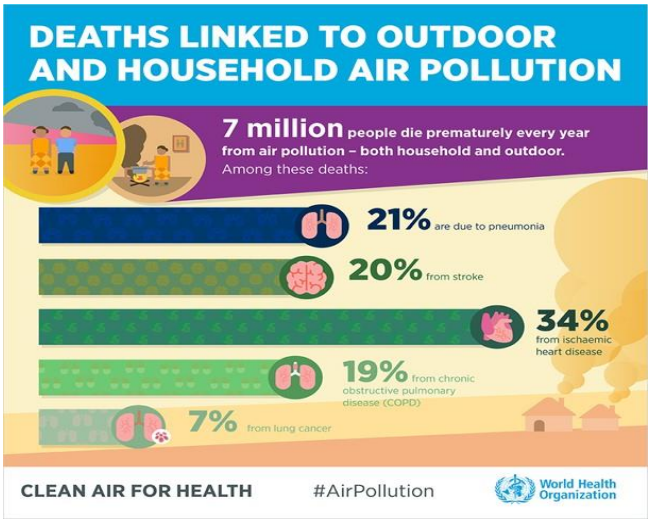

Fig. 1. WHO infographics on Air Pollution Effects to Health

By successively adding materials to a geometrical representation, digital fabrication tech- nology, also known as 3D printing or additive manufacturing, produces physical objects from a geometrical representation. 3D printing is a new technology that is rapidly gaining traction. 3D printing is now commonly used all over the world. In the fields of agriculture, healthcare, automobile, locomotive, and aviation, 3D printing technology is increasingly being used for mass customization and development of any form of open source design. 3D printing uses layer- by-layer deposition of material to print an object directly from a computer-aided design (CAD) model. (Shahrubudin, Lee & Ramlan, 2019)

OBJECTIVES

The purpose of this study is to:

Develop a low-cost air purifier using 3D printing, bamboo, and recycling waste material such into Activated carbon filter.

Integrate air pollution data collection with Raspberry Pi Internet of Things (IoT)

The proposed air purifier shall be using activated carbons from biomass in combination with HEPA filters in order to create a low-cost air purifier system. It would also be capable of measuring air quality with a PM 2.5 sensor and collect/share that data to users via an Internet of Things connection. A bamboo filter casing will be used to contain the activated carbon due to its high availability and faster production due to its already hollow and cylindrical form. The filter case housing will be made of bamboo treated with coats of varnish to prevent mold and degradation, with 3d printed end caps of HEPA filters and other filtration layers.

METHODOLOGY

The researchers utilized the Engineering Design Process, which is composed of the following phases:

Research: reading of related literature, consult experts, and collaborate with research in- stitutions such as the Department of Science and Technology(DOST) Research Institutions such as the Additive Manufacturing Center(AMCEN), Industrial Technology Development In- stitute(ITDI), and Philippine Textile Research Institute.

Plan: designing the prototype and the activated carbon production method;

Create: assemble and program the prototype;

Test and evaluate: measure the purification of the developed prototype;

Improve: evaluating the performance and redesigning as needed.

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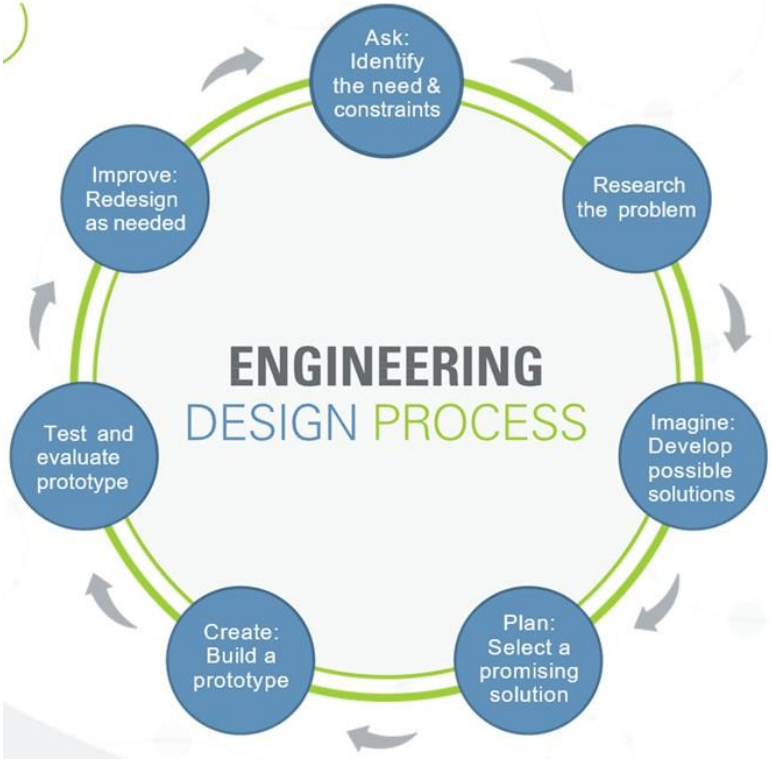

Fig. 2. Engineering Design Process

Materials

Table 1. Materials for Project Lila

Materials
Raspberry Pi Kits Arduino Kits
Electronic Supplies 3D Printer
3D filaments
PM, MQ 135 Sensors HEPA filters
Philippine Bamboo

Prototyping

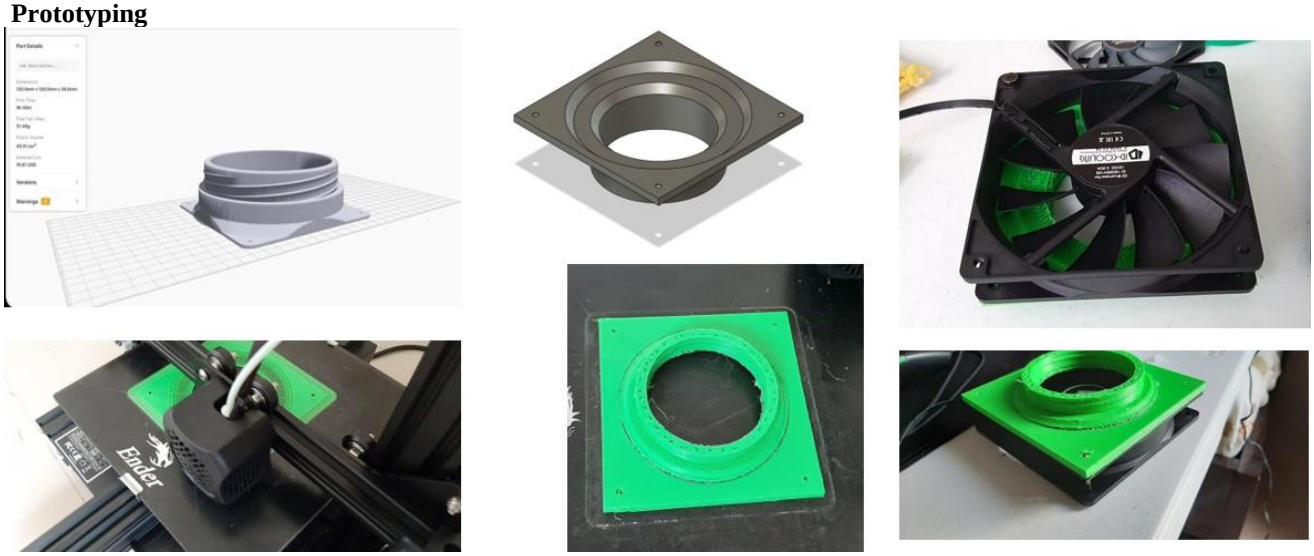

Fig. 3. 3D Design Optimization and Printing of Filter Module

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Synthesis of Activated Carbon

Fig. 4. Synthesis of Activated Carbon from Rice Husk Filter

Testing Using a makeshift gas chamber and an Arduino with Particulate Matter (PM) sensor. The researchers were able to test the initial prototype.

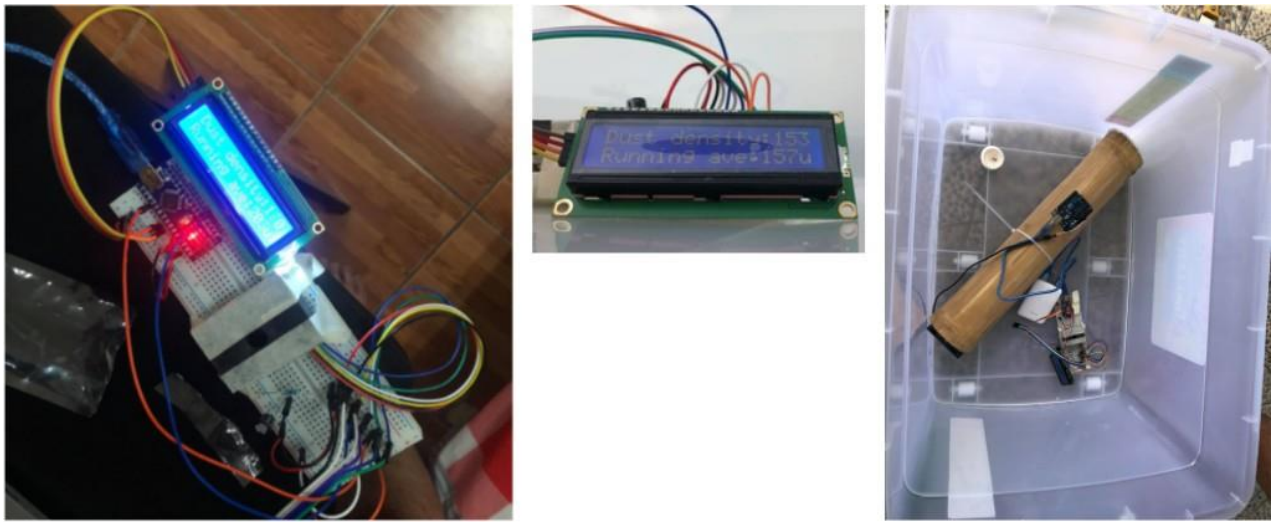

Fig. 5. Testing of the Prototype

RESULTS AND DISCUSSION

It could be gleaned from the Table below that the prototype has improved the air quality inside the improvised gas chamber. An initial 177 ppm air quality with smoke inside the chamber was contained. By triggering the Air Purifier protoype, a measured 140 ppm Air Quality was recorded.

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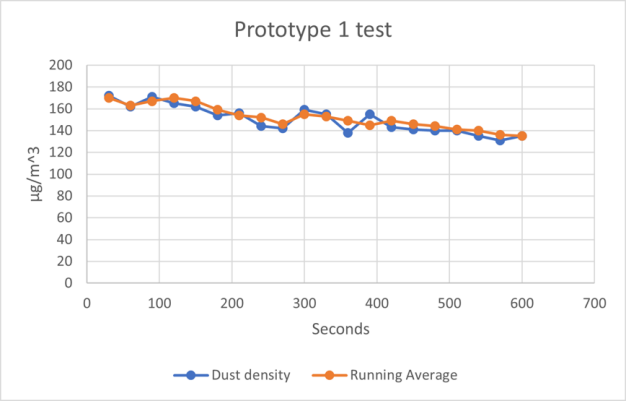

Fig. 6. Air Purifier Prototype Testing

CONCLUSION

The Project Lingap Langhap Air Purifier prototype shows a promising result for cleaning the air in a makeshift gas chamber. There is a promising opportunity to help the environment by reusing the agricultural wastes into a new material which is the air filter. 3D printing of the modules facilitated the prototyping process and fabrication of the proposed air purifier.

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