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**PROCEEDING  
ENGINEERING  
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**THE ROLE OF EDUCATION AND RESEARCH IN OVERCOMING CHALLENGES  
IN THE POST PANDEMIC WORLD**

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## TABLE OF CONTENTS

Feasibility Study on Manufacturing of Dried Plantable Moss Pot  
*Engr. Niña C. Apusaga, Engr. Jessica A. Torres, Engr. Ryan F. Arago, pp 6 -10*

A Study of Utilizing Biogas Fuel in a 2 Stroke Internal Combustion Engine  
*Dianne Mae M. Asiñero, Leonel L. Pabilona, Antonio-Abdu Sami M. Magomnang, pp 11-25*

A New Opportunity for Effective Standardized Facilities Management System  
for SUCs utilizing QR Code Technology  
*Janette Vargas-Lucre, pp 26-36*

Ultrasonic Blind Stick  
*Engr. John Billy M. Balidio, PhD, Rudigelio D. Cortez, Cris Jhone Boy H. Enot,  
Engr. Darren Chester E. Lazara, Jarwen V. Neri, Ralph R. Salibio, pp 37-43*

Early Prediction of Diabetes using ID3 Algorithm  
*Herminiño C. Lagunzad, Mikee V. Gonzaga, Fernandez C. Pineda, pp 44-52*

File Encryption and Decryption using Blowfish Algorithm in Securing School Records  
*Herminiño C. Lagunzad, Mikee V. Gonzaga, Fernandez C. Pineda,  
Maria Aura C. Impang, Joan F. Lawan, pp 53-65*

Quality and Safety Assessment of a Developed Solar Thermal Processing System  
for Cashew (*Anacardium occidentale*) Kernels Processing  
*Antonio-Abdu Sami M. Magomnang, Jude Andrea Eve P. Maternal, Jonathan H. Perez, pp 66-70*

Performance and Capabilities of Automated  
a Solar-Powered Floating-Type Aeration System for Aquaculture Ponds  
*Eligio C. Borres, Jr., Theody B. Sayco, Armando N. Espino, Jr., John Paulo C. Sacdalan, pp 71-80*

The Potential Use of the Microcontroller-based Automated Disinfection Device (MADD)  
in Eliminating Bacteria in Fomites  
*Niña Fe T. Emperado, Ryan F. Arago, Randel D. Estacio, pp 81-90*

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**Feasibility Study on Manufacturing of Dried Plantable Moss Pot**  
**Engr. Niña C. Apusaga<sup>1</sup>, Engr. Jessica A. Torres<sup>2</sup>, Engr. Ryan F. Arago<sup>3</sup>**

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*Abstract - The pottery business is one of the booming businesses right now, due to the lock down, many turn to planting and the demand for earthen pots increases. Thus, a study on feasibility of manufacturing of Dried Moss Plantable Pot was created which aim to make innovation in plant pot product design and function in order to tackle market competition effectively.*

*Plant pots made out of dried moss are sustainable and earth friendly. Dried moss can store water, even when dead, which is why it is often used as planting medium. Moss naturally fades from green to brown with age and is suitable for use anywhere in the garden.*

*These pots are biodegradable containers; the potters can easily plant their pots on soil and will undergo its decomposition. With more and more of us becoming conscious of our impact on the environment, many of us are constantly looking for new ways to reduce, reuse, and recycle responsibly.*

*With the Sustainable Development Goals as one of the main priorities, creation of sustainable businesses as well as continuous innovation in terms of design, durability, and material can increase the support and interest of customers.*

**Keywords** - Sustainable Development Goals, Circular Economy, Plantito/a, innovative pots

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## **Introduction**

In the last six decades, the massive production of plastics has led to an enormous amount of waste worldwide. Over 320 million tons of polymers were produced across the globe in 2015; but unfortunately, less than 10% of the manufactured plastics are actually recycled, and a huge amount is gathering in landfills or thrown away into the environment as litter. Non-renewable petroleum-based plastics are being used in a wide variety of fields. Particularly, modern agriculture uses a huge quantity of plastics stuffs, i.e. direct coverings, greenhouse covering films, soil mulching and solarization films, silage films, shading and protective nets, nets for harvesting and post-harvesting operations, irrigation and drainage pipes, strings and ropes, pots, packaging containers and sacks. The practice of using plastic materials in agriculture is often referred to as plasticulture. Plastic waste may reduce soil porosity and, therefore, decrease circulation of air. It can also affect microbial populations, and potentially decrease the fertility of the farmland. Fragments of plastic materials have also been shown to release phthalate acid esters into the ground.

Biodegradable containers or biopots are a sustainable alternative to petroleum-based pots that could easily adjust to horticulture and floriculture production, reducing the enormous amount of plastic waste, and providing outstanding marketing opportunities. Another advantage is the plant, along with the fibre pot, can go straight into the ground. This means no root disturbance, no transplant shock and no down time while roots settle in. This is ideal for fussy plants such as coriander, which tend to bolt to seed if their roots are disturbed.

And as the increase of the demand of potteries due to the continuous interest of many in ornamental plants as well as herbs and urban farming, the concern of sustainability and circular economy was also increasing. And that is why feasibility on manufacturing of dried moss plantable pot was conceived. With more and more of us becoming conscious of our impact on the environment, many of us are constantly looking for new ways to reduce, reuse, and recycle responsibly. When it comes to our plants, then, using biodegradable plant pots is an easy way to look after the world while also looking after our leafy friends, and it can come with some surprising benefits. Continuous innovation and launch of new flower pots & planters in terms of design, durability, and material are believed to propel the future growth of global flower pots and planters market.

## Materials and Methodology

This study use dried moss, as the main material for the plantable biodegradable pots. This material is easily accessible in the Philippines and found in shady damp corners and other places that water may flow, which will be harvested and dried up before grinding. A mixture of starch and water will be heated and will served as binder will be mixed with the dried moss before poring and setting it in the pot mould.

Design of Experiment and Kano Analysis was used to determine the required size, thickness, required strength and drying time (before removing in the mould and additional drying time before packaging) and was conducted from June to September of 2021 in Quezon City and municipality of Rodriguez, Rizal. Survey was conducted to determine the market acceptability and Quality Functional Deployment.

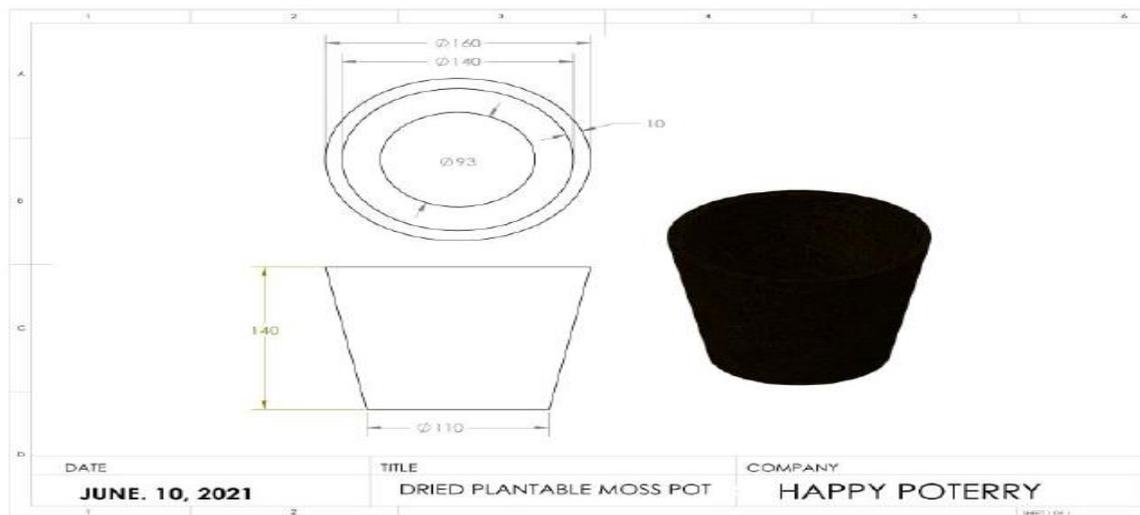
## Results and Discussions

The result of the experimentation yields the optimized specification that satisfies the target respondents and this can be seen in table 1. Depending on the usage, the Dried Moss Pot can last from 6 months to 5 years upon putting soil and plant on the pot and watering it. If it is buried in the soil, and in moist area, it increases the decomposition process.

**Table 1.** Product Specification

Product	Dried Moss Pot
Characteristic	Plantable Biodegradable pot
Designs	2 types, Circular and Square type
Sizes	For Circular upper side outside Diameter is 160mm and inside diameter is 140mm, Bottom diameter is 110mm. Thickness is 10mm and height is 140mm For square type Thickness is 10mm, Upper sides inner part is 150mm, outer part is 170mm. bottom outer side is 110mm.
Weight (Dried and ready for selling)	lightweight
Advantage	Totally organic, no harmful chemicals

**Figure 1.** Product Dimensions



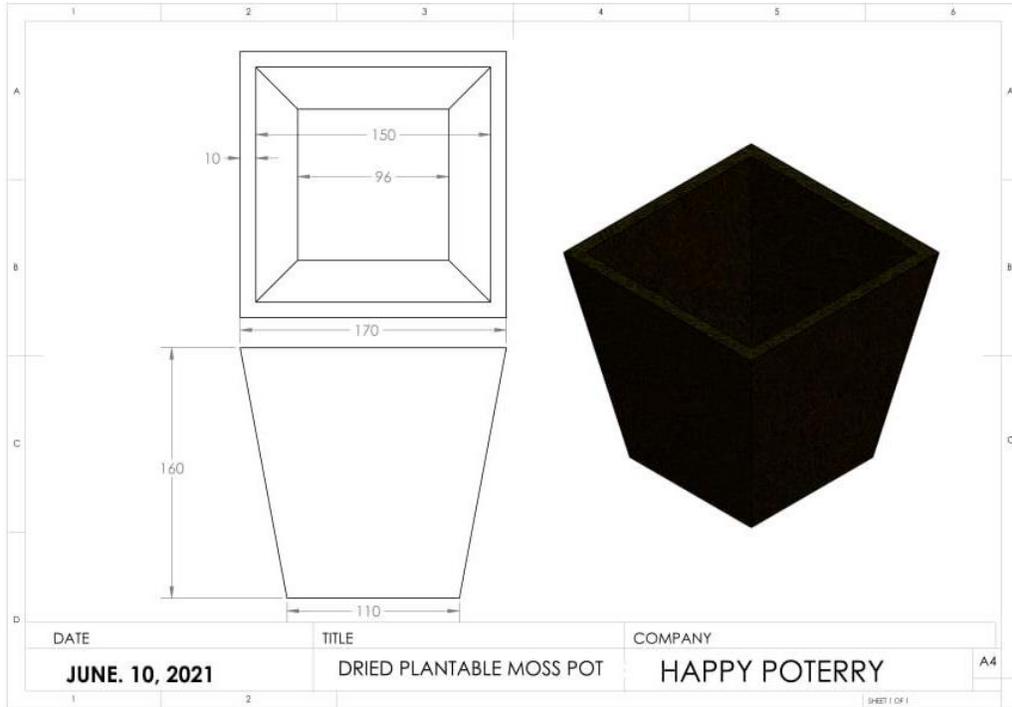


Figure 2 . Product Design





The mixture ratio of the binder to the dried moss that yields the best durability is the 56.25 grams of starch per 1.25 cups of hot water, mixed until the starch is dissolved, sticky and consistent (approximately 10 minutes). The mixture will be poured in the basin and the 50 grams dried moss will be added gradually while mixing. This will be poured in the mould and if without hot press, and only air dried, it will be stayed in the mould by 25 minutes before detached and let it sun dried again until fully hardened. For hotpressed mould, you can automatically release it in the mould and sundried.

### **Conclusion and Recommendations**

The process and materials required to produce the goods are readily available in the market in terms of technological and manufacturing viability. The use of biodegradable and plantable pots can greatly help the problems in creation of waste such as plastics, and encourage circular economy.

There are also different materials that we can try to create biodegradables and plantable pots that its either plant wastes, animal wastes or organic wastes. With the continuous demand for plants and plant pots, what we can do is provide suitable alternatives that are sustainable, waste free, and create jobs as well for our community.

### **Acknowledgement**

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## **A Study of Utilizing Biogas Fuel in a 2 Stroke Internal Combustion Engine**

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*Abstract - The Biofuels Law (RA 9367) aims to minimize the dependence on fossil fuels and encouraged the use of bio-based fuel sources as an alternative fuel in rural areas where farming is their only source of income and energy is scarce. Biogas is a renewable energy carrier consists of a methane and carbon dioxide mixture. Because of its improved mixing ability with air, clean-burning nature, and high-octane number that resists knocking, it is an excellent alternative source of energy to employ in internal combustion engines. The single-cylinder two stroke spark ignition (43cm<sup>3</sup>) was designed to be fed with a variety of fuel in order to assess engine performance parameters such as speed, brake power, BSFC, and thermal efficiency at different throttling positions (Low load throttle and High load throttle). This study evaluates the engine performance of biogas, Liquefied Petroleum Gas (LPG) and Gasoline with two-stroke engine oil (2T) in a dynamometer without modifying the compression ratio. To optimize its use as a fuel for power generation, biogas is purified using hydrogen sulfide adsorption and carbon dioxide absorption. The results showed that among the three (3) fuels studied, Biogas Fuel from swine manure generates the highest electrical power load of 761 Watts with a methane concentration of 51% and a bsfc of 1.4 kg/kW-h. Thus, LPG achieves the highest engine speed at 14,700 rpm with 549 Watts. As a result, the purified biogas fuel can be used in a small-scale internal combustion engine.*

*Keywords - Biogas Fuels, Liquefied Petroleum Gas, Spark Ignition Engine, Gasoline with 2T engine oil, 2 – stroke engine*

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### **Introduction**

The availability of biogas as a renewable energy source is increasing due to establishment of many organic waste processing facilities around the world. The need of electricity to support daily life activity is a must, but the availability of electric sources in the remote areas is limited, especially for farms that are far away from commercial electric distribution lines (Lie, D., et. al., 2021). Many studies are being conducted to reduce the harmful effects of exhaust emissions gases caused by the use of gasoline, diesel, and LPG fuels in internal combustion engines (ICEs). The fact that the use of fossil fuel-based fuels is harmful to the environment and hazardous to human health has led the researchers to search for alternative fuel sources. (Uslu and Celik, 2018). These alternative fuels for spark ignition engine can be classified as synthetic gasoline, liquefied petroleum gas (LPG), compressed natural gas (CNG) and biofuel. Biofuel has long been used in internal combustion engines due to its ability to reduce emissions and increase thermal brake efficiency. The use of alternative fuels such as biogas is one way to reduce fossil fuels consumption (Simsek and Uslu, 2020).

Biogas is a flammable mixture of different gases that are produced by the decomposition of biodegradable organic matters in the absence of air (no oxygen) and the presence of anaerobic micro-organisms. It consists of a mixture of 55–65% methane (CH<sub>4</sub>) and 35–45% carbon dioxide (CO<sub>2</sub>) with small traces of nitrogen, oxygen, water vapor and hydrogen sulfide, which are produced naturally (Kaparaju and Rintala, 2013). Among these components, only methane is essential in the combustion process, and the other components are not flammable at normal conditions but significantly reduces the calorific value of the fuel. It has a great potential to be applied in internal combustion engines because of its better mixing ability with air and clean-burning nature. When biogas is purified, it has a lower cost and lower emissions than any other secondary fuels. It also has a lot of potential because of its higher knocking resistance that allows spark-ignition engines to run at higher compression ratios, which increases the brake thermal efficiency value of the engine. It can be supplemented with liquefied petroleum gas (LPG) and compressed natural gas (CNG) if it is used in compressed form in cylinders (Barik and Sivalingam, 2013).

In addition, some studies on the use of biogas in SI engines have been conducted in recent years. Hotta et al. investigate raw biogas in a 10-compression ratio gasoline engine, and the results show that the BSFC increases by 66% while BTE decreases by 12%. On the other hand, Reddy et al. investigate the use of biogas in SI engines under different loading conditions at different fuel flow rates, and results show that the thermal efficiency is reduced by 4%, and the test generator using biogas and LPG shows biogas as emission less fuel, resulting to less CO. Nayak et al. investigated the effects of different gasoline and LPG mixtures (25%, 50%, 75% and 100% LPG) on the SI engine at different engine speeds. According to the experiment results, the pressure increases as the LPG ratio in the test fuel increases. Chandra et al. conducted an experimental investigation in an Internal Combustion engine. The thermal efficiency, specific gas consumption and brake power of methane enriched biogas were comparable to compressed natural gas. As a result, methane-enriched biogas has shown an increase in 1.6 times of power output over raw biogas when used in SI engine. It was concluded that the methane enriched biogas has excellent fuel properties similar to natural gas. Çinar et al. also investigated the effects of gasoline and LPG on engine brake torque, power, BSFC, gas emission and exhaust gas temperature on a single-cylinder and four-stroke at various engine speeds. They stated that the use of LPG increased BSFC and gas emission while decreasing brake engine torque. Although there are many studies in recent years on the use of biogas and LPG in 4-stroke SI engines, there are no studies on the use of LPG, gasoline and biogas in 2-stroke spark-ignition engine. Therefore, information about comparing the use of various biogas, LPG and gasoline with 2T engine oil on engine performance parameters with different throttling opening positions is missing in the literature. This study was conducted to address this deficiency.

Thus, the aim of the study was to increase the biogas yield through the purification and upgrading of biogas from various biomass substrates such as cow, swine and 1:1 ratio of cow and swine manure mixtures as an alternative fuel source. It also aimed to test the purified biogas fuels in a 2-Stroke Spark Ignition engine generator and compared with benchmark fuels (Gasoline with 2T engine oil and LPG). Moreover, it also intended to determine the engine performance parameters such as Speed, Torque, Brake Power, Brake Specific Fuel Consumption, and Brake Thermal Efficiency under different throttling opening conditions (Low Load Throttle and High Load Throttle) considered for power generation applications. The following are the specific goals of the research: (a) to investigate the benchmark fuels in a 2-stroke spark ignition engine at various throttling opening positions. (b) to test the purified biogas fuels in a 2-stroke Spark Ignition engine by determining the parameters at various throttling opening conditions. (c) Characterize and compare the engine performance of a 2-stroke spark ignition engine fueled by various biogas fuels to benchmark fuels.

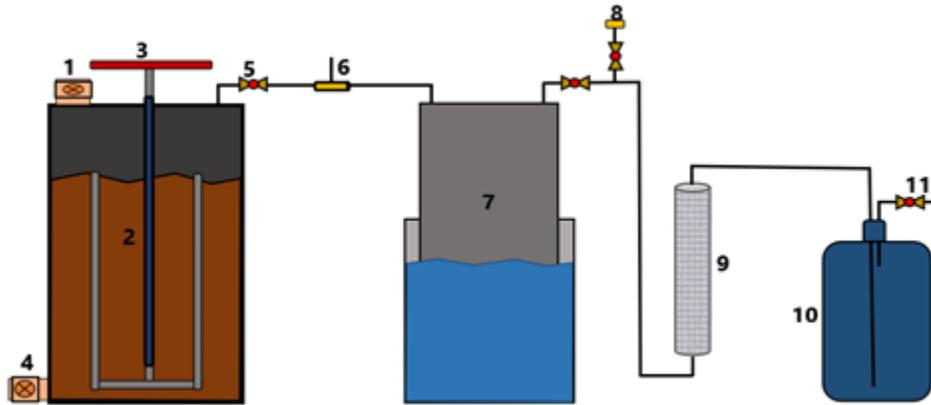
## Methodology

This research aimed to develop a simple method for converting a gasoline engine to biogas fuel and LPG without changing the compression ratio of the original spark engine. The fueled gasoline engine is from the specification that can easily be found in the market, and operates in 2-stroke spark ignition, air-cooled with a single-cylinder. And to determine the performance characteristics of a 2 – stroke spark ignition engine, two separate tests are carried out by the engine. First, all engine performance parameters were tested using benchmark fuels: gasoline with 2T engine oil and LPG. Second, all engine performance tests were conducted in the same gasoline engine with different biogas fuels (cow, swine, and a 1:1 mix of cow-swine manure) at various engine throttling opening positions (0 and 100%) at room temperature.

### 1.1 Production of Biogas

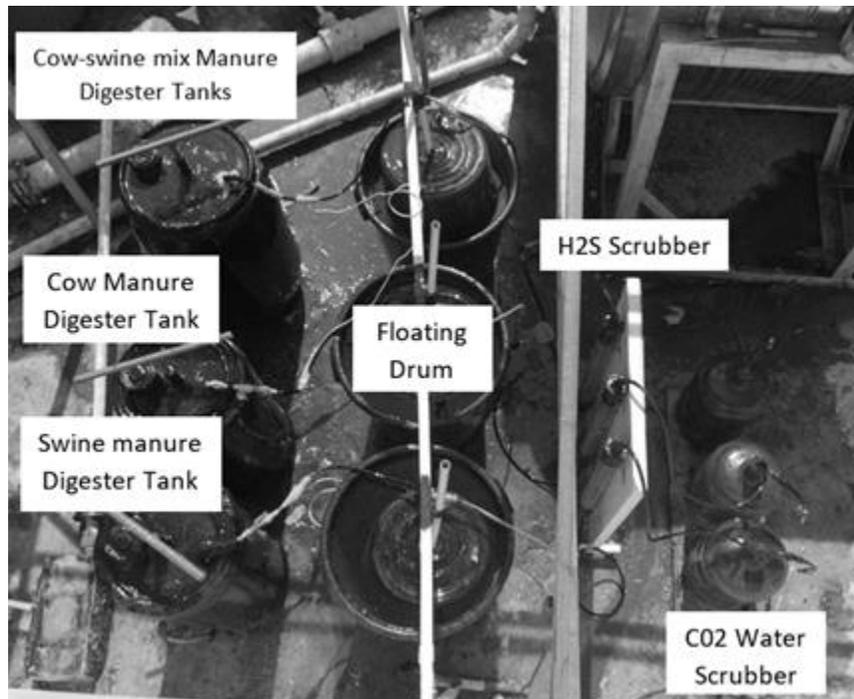
The experimental setup of the biogas system is designed to produce biogas that will be used to fuel the engine during the engine performance test. It consists of a biogas digester, gas holder and purification system of hydrogen sulfide and carbon dioxide using steel wool and water scrubbing system. The biogas system in this study is composed of three organic biomass materials: cow, swine and 1:1 cow-swine mixed manure were used separately at different technical settings in a separate anaerobic digester under mesophilic temperature, which uses ambient temperature ranges from 20°C to 45°C to produce biogas. Each collected manure weighs 50 kilograms. It will be mixed with manure to water ratio of 1:1.5. A

temperature sensor and pressure sensor were used to monitor the temperature and pressure inside the biogas digester. Furthermore, because the research is a batch feeding process, no organic load was fed inside the digester. After being placed in the digester, the selected manures were stirred daily. To ensure that the bacteria and the substrate were well-mixed and homogenous. Figure 1 and Figure 2 show the schematic diagram and Actual experimental setup, where the gas produced (raw biogas) was stored in the gas holder before going to the removal system. The CO<sub>2</sub> and H<sub>2</sub>S impurities are removed using a water scrubbing system. Since H<sub>2</sub>S is highly corrosive both in the engine and to the purification system, it must be removed first in order to prevent damage. Then, the CO<sub>2</sub> will be removed to increase the heating value of biogas fuel. A gas analyzer is used to analyze the methane content of the biogas. The methane composition of various purified biogas (cow, swine and cow-swine mixture) was analyzed using a BH-90 Henan Bosean portable infrared type methane gas analyzer capable of detecting 100% methane volume. Table 2.1 shown the Properties of biogas composition.



**Figure 1. Schematic Diagram of Biogas System**

1. Manure Inlet
2. Digester Tank
3. Stirring rod
4. Digestate Outlet
5. Gate valve
6. Pressure and Temperature Sensor
7. Floating Drum
8. Outlet for Testing Methane - Gas Analyzer
9. H<sub>2</sub>S Removal
10. CO<sub>2</sub> Water Scrubbing Removal
11. Outlet for Testing Purified Biogas - Gas Analyzer.



**Figure 2. Actual Experimental Set – up of Biogas Production**

**Table 2.1. Properties of Biogas composition**

Properties	Biogas from Swine Manure	Biogas from Cow Manure	Biogas from Mixture of Swine & Cow Manure
Composition (Vol. %)	CH <sub>4</sub> – 51% CO <sub>2</sub> – 49% Other gases–0%	CH <sub>4</sub> – 55% CO <sub>2</sub> – 45% Other gases–0%	CH <sub>4</sub> – 53% CO <sub>2</sub> – 47% Other gases–0%
Lower heating value at 1 atm and 15 °C (MJ/kg)	13.76	15.59	14.58
Density (kg/m <sup>3</sup> )	0.671	0.671	0.671

## 1.2 Engine Specification

The test was carried out on a 2 – stroke engine (Fortress FPBC4300), a 43cm<sup>3</sup>, single-cylinder, spark-ignition gasoline engine with a compression ratio of 17:22. The engine used was readily available on the market. The engine’s original fueling system was configured for gasoline with 2T engine oil. Since, it was desired to run on biogas, no modifications or changes were made such as spark plug gaps setting, valve clearance or fibra spacer modification, to obtain desired data with various throttling opening positions.

The engine assembly was composed of a container containing a mixture of gasoline and 2T engine oil, which was connected to the 2-stroke spark-ignition engine, and the engine’s intake manifold which was connected to the gaseous fuel LPG. The DT-2234C digital tachometer and prony brake dynamometer were used to measure the brake engine speed and torque at room temperature. The engine was tested with

different throttling opening positions. The Low Load throttle and High Load throttle opening position are used to gathered engine parameters. A Low Load throttle opening position is when the airflow remains constant in a fuel flow regulated to torque, whereas the High Load throttle opening position occurs when the gate of the fuel line is fully open at 100% and the accelerator is at its highest position, allowing maximum airflow in the system during suction. The engine parameters were tested and gathered for at least 10 seconds because the dynamometer used caused friction contact through slippage which can cause excessive percentage error over a longer period of time. The Fortress FPBC4300 2-stroke internal combustion engine was used to power a lawnmower. As shown, the engine's technical specifications are listed in Table 2.2.

**Table 2.2. Specification of the 2 – stroke spark Ignition engine used**

Engine Parts	Description
Model	FPBC4300
Engine type	Single-cylinder; 2-stroke; Air-cooled; piston valve
Volume Displacement	43cm <sup>3</sup>
Compression Ratio	17:22
Maximum output (KW/RPM)	0.7/6500
Carburetor	Diaphragm type
Ignition system	Non-contact electronic ignition
Method of starting	Recoil type
Fuel tank capacity (L)	1.2 Liters
Maximum speed of gear shaft/ engine speed	8500/11000
Idle speed	2350 – 2900 rpm
Bore and Stroke	B = 40 mm; S = 34.2 mm

### 1.3 Benchmark Fuels Setup

Benchmark fuels are used to compare the performance of various biogas and alternative fuels. To determine the performance characteristic of the benchmark fuels: Gasoline with 2T engine oil and Liquefied Petroleum Gas (LPG) were used in this study. After all the data were gathered, this data was used as a benchmark for biogas fuel using various substrates and throttling openings.

#### 1.3.1 Gasoline with 2T engine oil

The setup used a 2T engine oil as a mixture of gasoline with a fuel ratio of 30:1. It means that 30 parts of gasoline were mixed with 1 part of 2T engine oil. The engine was desired to run on various biogas fuels with no modification for easily switching back to its original fueling system and for easy conversion method of gasoline to biogas with the same throttling opening positions. At first, the test engine was run idle through 3 to 4 hours conditioning period to provide a properly “break-in” engine. Afterward, the mixture of the fresh air and gasoline with 2T engine oil were feed into the 2 - stroke engine to start the experiment with Gasoline. During the experiment the fuel tank was filled with gasoline mixed with 2T engine oil. After filling the fuel tank with exact volume, the choke was adjusted and that the throttle was placed at Low Load position. The engine was started using the manual crankshaft, and once it ignited the torque using the prony brake dynamometer was connected to the shaft and the speed of the engine are produced by using a tachometer. The speed that was gathered indicated that it had a corresponding brake torque applied with load throttle position used in the study. The same procedure was used in gathering data of High Load throttle position. The method of getting the engine brake power lasted for 10 seconds time-lapse. After performing the experiment, the engine was cooled to avoid overheating that may cause failure to engine especially the piston. All gasoline with 2T engine oil tests were completed before switching to LPG fuel and biogas fuels because the engine purchase was preconfigured by the manufacture for SI mode and originally designed to run with the mixture of gasoline and 2T engine oil. Figure 3 shows the Actual Setup of the 2–stroke spark ignition engine.

### 1.3.2 Liquified Petroleum Gas

For gaseous fuel, the Liquefied Petroleum Gas was used in 2 – stroke spark-ignition engine. The setup was composed of an 11-kilogram LPG tank of Pryce Gas with a mixture of 40% propane and 60% butane. The LPG fuel was connected directly to intake manifold of the 2-stroke spark-ignition engine which a weighing machine was used to measure the fuel consumption of the LPG. The gaseous fuels: Liquefied Petroleum Gas and the various biogas fuels, were next to be tested after the gasoline. At first, gasoline with 2T engine oil was used to ignite the engine since the engine was not able to start with gaseous fuels. When the engine was adequately running, the fuel valve of the gasoline tank was turned off using a fuel petcock synchronizing with the opening of the LPG line valve. As the operation continues, the remaining gasoline with 2T engine oil was depleted and the gate valve of the LPG tank of the fuel line was opened to supply to the 2 – stroke engine. With this valve, the LPG flew directly to the carburetor of the combustion chamber of the engine. It was noted that during the feed of gaseous fuels, the flow rate must let at maximum to keep the gasoline engine running and then reduced until the engine was stable. The weight force of the dynamometer reads on the weighing scale in terms of kilograms to get the brake torque of the engine. Simultaneously, the tachometer read the speed of the engine in terms of RPM. The 2 – stroke spark ignition engine performance parameters were conducted with High Load throttling and Low Load Throttling conditions. The LPG had the same experimental procedure with biogas fuels when feed into 2 – stroke spark-ignition engine.

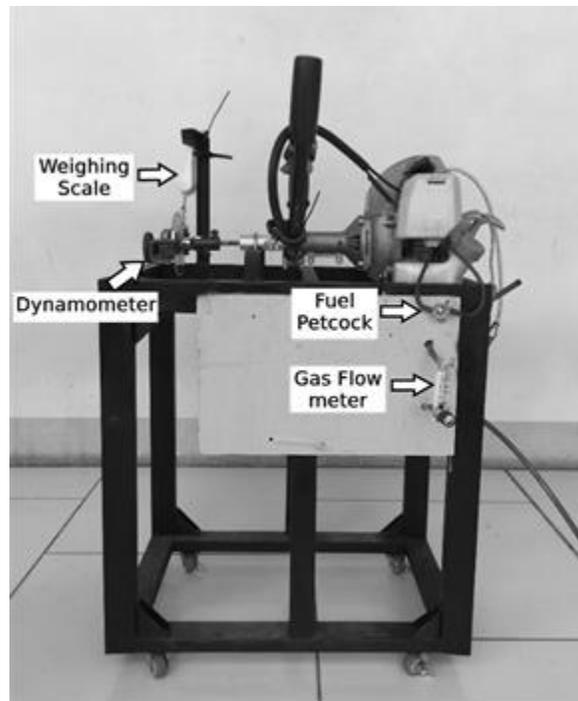


Figure 3. Actual Setup of the 2–stroke spark ignition engine

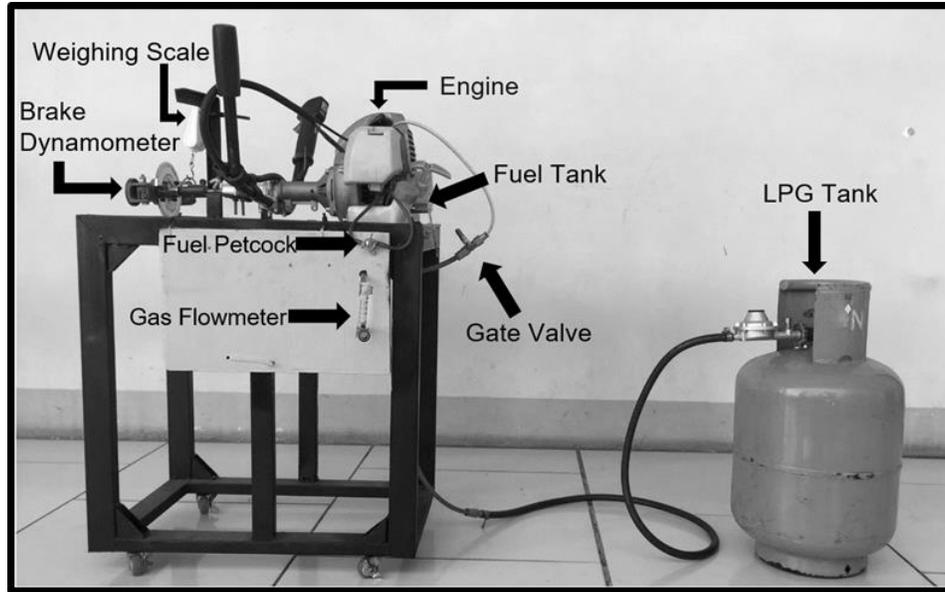


Figure 4. Actual Experimental Set – up of 2-stroke engine fueled by LPG

#### 1.4 Engine Parameters

In conducting a performance test of an engine, different parameters were obtained. Standard engine parameters were considered for testing and investigating the performance parameters of 2 – stroke spark ignition engine. The researcher referred to the book of Engineering Fundamentals of the Internal Combustion Engine by Willard W. Pulkrabek.

##### 1.4.1 Brake Engine Power

Torque and speed indicated the power of an engine. It is defined as a force acting at a moment's distance. It is important to determine the power since it is the indicator of rate of work of an engine (Pulkrabek, 1995).

$$P_b = 2\pi TN \quad (\text{Eq. 2.1})$$

2.1)

Where: N = Engine rotational speed, rev/s  
 T = Engine brake torque, N-m or Joules  
 P<sub>b</sub> = Engine brake power, Watts

##### 1.4.2 Brake Specific Fuel Consumption

Brake specific fuel consumption is the amount of fuel an engine burns per unit of mechanical work (energy) it produces. There was a need to determine the rate of fuel burnt in the engine. The lower the BSFC implies that a lesser amount of fuel is needed to generate certain power during specific time (Pulkrabek, 1995).

$$\text{BSFC} = \frac{\dot{m}_f}{P} \quad (\text{Eq. 2.2})$$

2.2)

Where:  $\dot{m}_f$  = mass of fuel/mass of biogas, kg/s  
 P = brake engine power, Watts  
 BSFC = Brake Specific Fuel Consumption, kg/kW-hr

### 1.4.3 Brake Thermal Efficiency

Thermal Efficiency is the ratio of the output work to the input heat. Most engines are designed with theoretical-based power (Pulkrabek, 1995).

$$\eta_{th} = \frac{P_b}{m_f Q_{HHV}} \times 100 \quad (\text{Eq. 2.3})$$

2.3)

Where:

- $m_f$  = mass of fuel, kg/s
- $P$  = brake engine power, Watts
- = fuel heating value, J/kg
- = Brake Thermal Efficiency, %

## Results and Discussions

This study aimed to investigate and characterize the performance of a 2-stroke spark ignition engine fueled by gasoline with 2T engine oil, Liquefied Petroleum Gas and biogas from different manure mixtures (cow, swine and mixed cow-swine manure) at different throttling load.

### 1.5 Engine Performance of Benchmark Fuels: LPG and Gasoline with 2T engine oil

One of the objectives of this study was to determine the engine performance using benchmark fuels and biogas at the same throttling opening positions. It also aimed to show the comparison between LPG and Gasoline with 2T engine oil.

#### 1.5.1 Engine Characteristic of Brake Engine Power and Brake Engine Speed of Benchmark Fuels

At low load throttle opening position, the LPG fuel had the highest speed from the two benchmark fuels at exactly 12,226 rpm and 0.273 Joules torque. This shows that when the performance of LPG increases, the rotational speed of the engine also increases that forced the engine to change from idle to wide-open throttle positions (Masi, 2012). The engine's original fueling system was gasoline with 2T engine oil, and the manual specified that the engine idle speed was around 3000 – 4200 rpm, but the actual brake engine speed gathered was around 2350 – 2900 rpm with a torque of 0.624 to 0.771 Joules because the spring attached to the diaphragm type carburetor was removed to prevent the engine from stopping when tightened by the dynamometer. The brake engine speed of the gasoline with 2T engine oil tends to decrease when the flywheel of the dynamometer is held tightly. And increases when the flywheel is released. When the engine was running at low load throttling position, the engine was not strong enough to grip the brake that results in a slight maintain on its rotational speed. At high load throttle position, the engine is at full capacity and needs to hold the brake tighter due to friction caused by slippage error that may stop the engine and as an effect, the engine's rotational speed increases causing the graph to oscillate. The LPG at 548.368 Watts had the highest brake engine power than gasoline with 2T engine oil. While the brake engine speed, the LPG at 14,699 rpm is higher than gasoline at 4950 rpm. According to Hotta et al., the rotational speed of the engine is highly dependent on the load applied to the dynamometer, since in both throttling positions, the LPG fuel has the highest brake engine speed than gasoline with 2T engine oil. Generally, the higher the brake engine speed obtains the higher brake power it produces and result of decrease in the brake engine torque (Chandra et al., 2011).

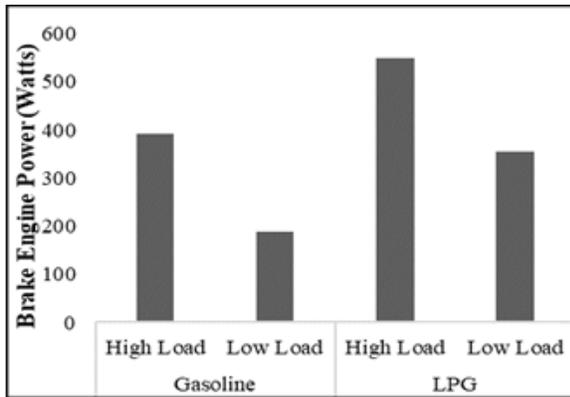


Figure 5. Engine characteristic of Brake Engine Power of Benchmark Fuels

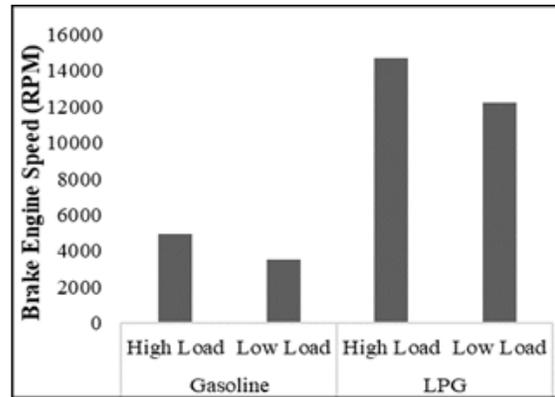


Figure 6. Engine Characteristic of Brake Engine Speed of Benchmark Fuels

### 1.5.2 Engine Characteristic of BSFC of Benchmark Fuels

The graph shows that the brake specific fuel consumption decreased as brake power on the engine was increased. Because the BSFC was calculated using the brake engine power and it indicates the efficiency of the engine that generates the brake power from fuel. At low load throttle, the fuel consumption was 0.016 kg/kW-h for gasoline with 2T engine oil and 0.006 kg/kW-h for LPG. There was no significant difference between the two fuels. For high load throttle position, gasoline with 2T engine oil yielded the highest fuel consumption at 0.015 kg/kW-h. As a result, at higher loads, heat loss is reduced, resulting in higher fuel consumption and better utilization to the engine (Jindal et al., 2015). According to Duc et al., the ignition delay of the engine fueled with gasoline and LPG defined as the time interval between the start of ignition and start of combustion of the engine fueled with LPG is longer than gasoline due to lower combustion rate and higher ignition point. Furthermore, when LPG is used in 2 – stroke ignition engines, the burning rate of fuel increases, and thus the combustion duration decreases. As a result, the temperature and pressure of LPG are higher than gasoline.

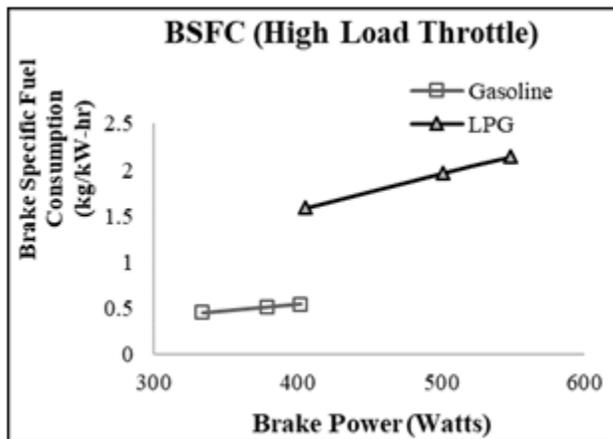


Figure 7. Engine Characteristic of High Load BSFC of Benchmark Fuels

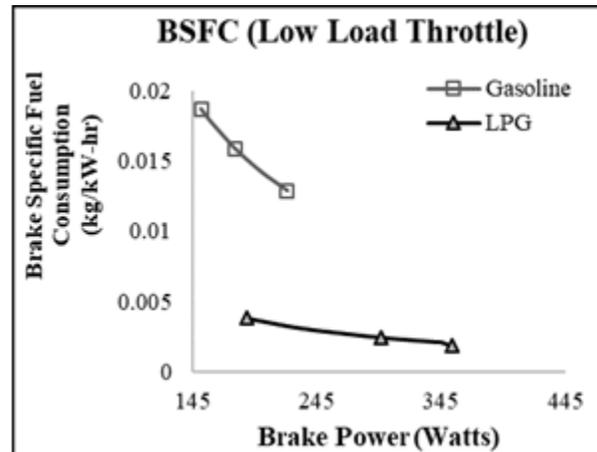


Figure 8. Engine Characteristic of Low Load BSFC of Benchmark Fuels

## 1.6 Engine Performance of various Biogas Fuels (Cow, Swine and mixed Cow- Swine Manure)

The anaerobic digestion in the biogas system used different biomass such as Cow Manure, Swine manure and Cow-Swine mixed manures with different setup under mesophilic temperature ranges of 25OC – 45OC to produce biogas fuel for the 2–stroke ignition engine to achieve the engine performance.

### 1.6.1 Engine Characteristics of Brake Engine Power and Brake Engine Speed of various biogas fuels: cow, swine and 1:1 cow – swine mix manure.

As compared to experimental data based on Reddy et al., swine manure already achieved its highest power on high load throttle at 761.485 watts, followed by cow manure and cow – swine mix manure. Under high load condition, it obtains a maximum brake engine power because the brake power developed by the engine is found to be increasing with an increase in load. An increase in loading, increases the combustion quality of the fuel, thus increasing the power output. And the brake power is just the function of engine torque and engine speed in RPM. And for the Low Load throttle position, it also shows that swine manure yields the highest power at 327.167 Watts, followed by cow-swine mixture manure and cow manure. Biogas has a comparative lower laminar flame speed and it cannot be ignited at the same crank angle of gasoline (Hotta et al., 2019). As a result, when too much fuel is injected into the engine, the engine shuts off and there is insufficient air to maintain the air-fuel mixture for the combustion process.

For the brake engine speed of the various biogas fuels at high load throttle position, the highest brake engine speed was 10,443 rpm of 0.725 Joules for swine, 10,330 rpm of 0.571 Joules for mix cow-swine manure and 9516 rpm of 0.699 Joules for cow manures. During the operation, the mixed manure substrates biogas fuel attained a stable brake engine speed that ranged from 9,500 to 10,500 rpm with applied brake torque. Therefore, the brake engine power should have an increasing trend as engine speed increases. In both throttling opening positions, both biogas fuels attained their maximum brake engine speed and decreased with the brake load increased due to the tightening of dynamometer’s bolt.

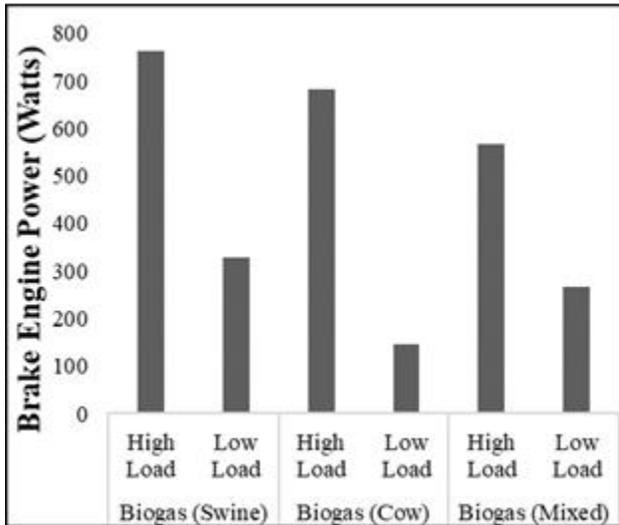


Figure 9. Engine Characteristic of Brake Engine Power of various Biogas Fuels

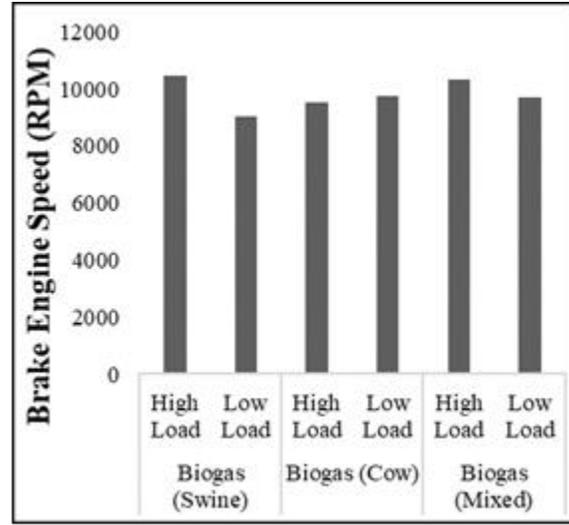


Figure 10. Engine Characteristic of Brake Engine Speed of various Biogas Fuels

### 1.6.2 Engine Characteristics of BSFC of various biogas fuels: cow, swine and 1:1 cow – swine mix manure

The mixed of cow – swine manure yields the highest bsfc at 1.919 kg/kW-h with 53% methane content for high load throttle opening position. The swine manure with a methane content of 51% had the

lowest BSFC at 1.431 kg/kW-h. As the brake engine power increased, the BSFC also increased. As shown, the mixture of cow – swine manure had the highest brake fuel consumption for high load throttle position, but it was the least brake power engine generated, because the brake engine power is directly proportional to brake engine speed. The greater the brake engine speed, the greater the Brake Specific Fuel Consumption of a fuel. According to Arul Peter et al., the higher the percentage of purified biogas in the mixture, the higher brake specific fuel consumption due to the gaseous state of biogas. At low load throttle position, the cow manure at 2.549 kg/kW-h with 53% methane content had the highest bsfc and swine manure has the lowest bsfc at 1.127 kg/kW-h with 51% methane content. Since the 2–stroke gasoline engine ran on various biogas on low load position, the cow manure consumed more fuel than high load throttle position because as stated by Barik and Sivalingam, when the bsfc decreases with increase in engine load, the lesser fuel it required at high loads throttle position due to the increased cylinder temperature of the engine compared to low loads. Also, the bsfc is greatly dependent on brake engine power, inversely increase with brake load.

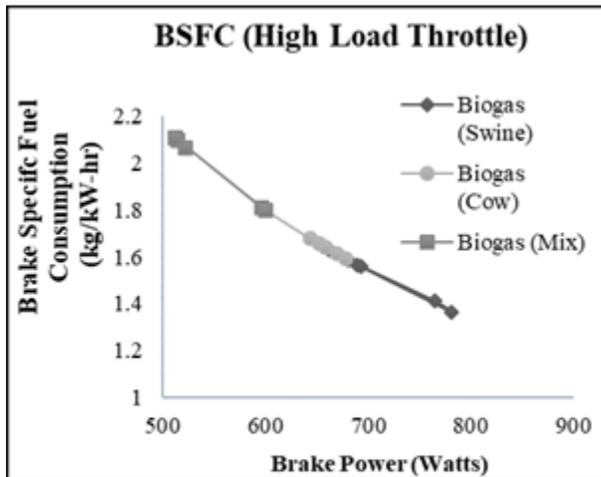


Figure 11. Engine Characteristic of High Load BSFC of various Biogas Fuels

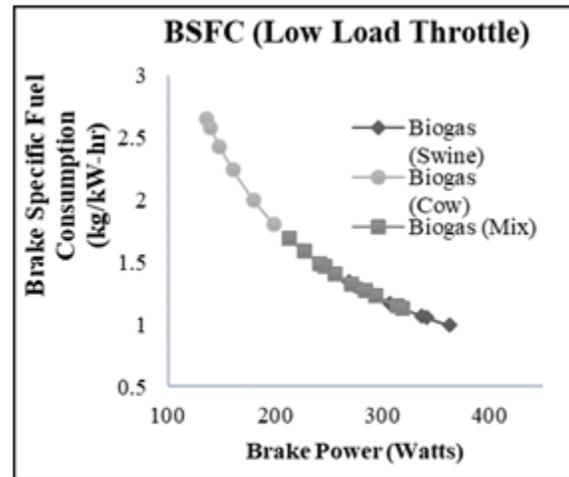


Figure 12. Engine Characteristic of Low Load BSFC of various Biogas Fuels

## 1.7 Comparison of Engine Performance of various Biogas Fuels and Benchmark Fuels

The main objective of this study was to determine the engine performance parameters using benchmark fuels at same throttling opening position conditions with various biogas. The conversion methods used in this research was successful and were able to run the 2 – stroke gasoline engine fueled by gasoline with 2T engine oil, various biogas and LPG.

### 1.7.1 Characteristics of Brake Engine Power and Brake Engine Speed of various fuels: Benchmark fuels and different biogas (cow, swine and mix manures)

Among the three fuels, the highest brake power fueled by 2–stroke spark ignition engine at high load throttle condition was the swine manure biogas at 761.485 Watts. And the least brake engine power was gasoline with 2T engine oil at 392.888 Watts. While on Low Load throttle position, the maximum brake power output of the engine operated are 353.872 Watts of LPG. Generally, the brake engine power increases with an increase in brake engine speed. Since the various biogas fuels and LPG are injected directly into the intake manifold, a large volume of intake air will be replaced by both gaseous fuels when tested. Compared to gasoline with 2T engine oil, gaseous type fuels have a better mixture formation that resulted an increase of heat release rate, increase in cylinder temperature and increase in cylinder pressure that contributed to a complete combustion process of the engine (Duc and Duy, 2018). The trend of the graph gave a clear advantage of use of purified biogas in engine operation for better power output over raw

biogas and other benchmark fuels. While for brake engine speed, the various biogas fuels (cow, swine, cow-swine manure mixture) had almost the same trend of brake engine speed ranges from 10,500 rpm to 9,000 rpm. On the other hand, gasoline with 2T engine oil yield the lowest brake engine speed at 4950 rpm compared to LPG at maximum of 14,699 rpm. It was found that biogas has a lower calorific value and has a lower combustion quality than LPG, resulting in variation of engine speed. As a result, engine speed decreased by 25.67% at high load throttle position and 27.06% at low load throttle opening position when operating in purified biogas.

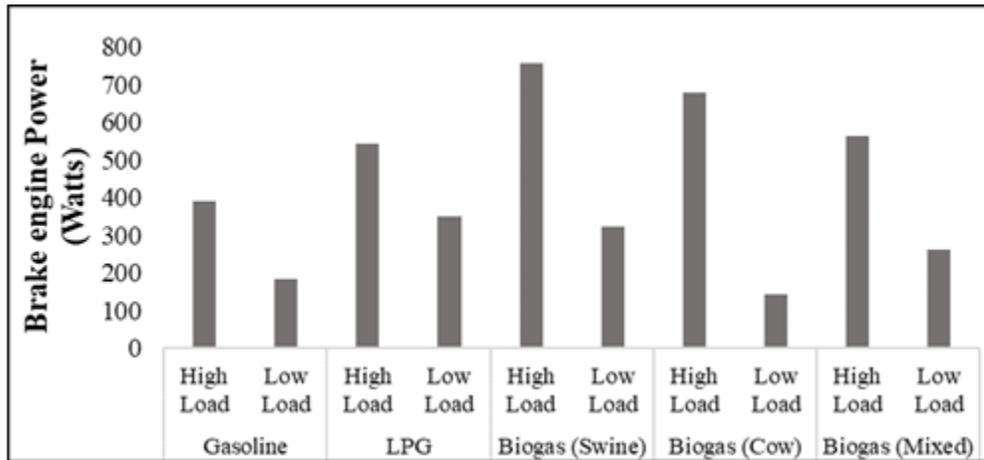


Figure 13. Characteristic of Brake Engine Power

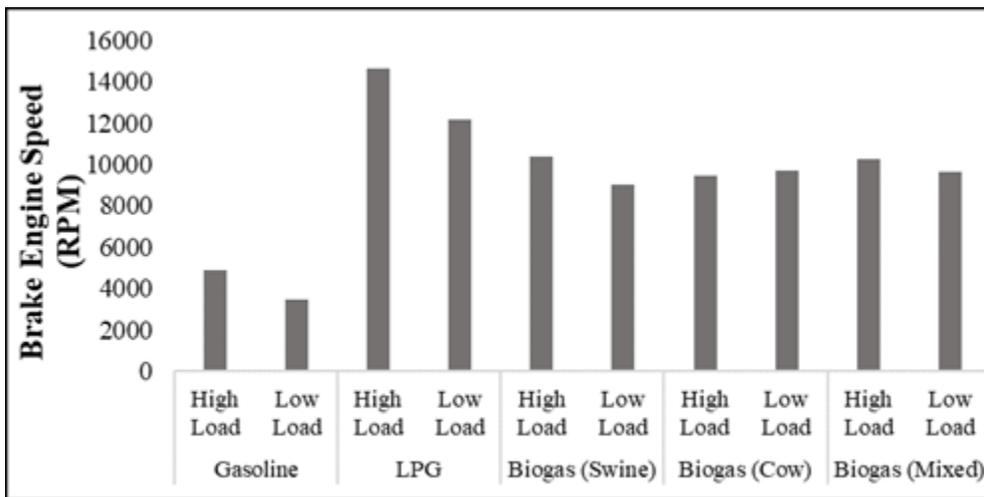


Figure 14. Characteristic of Brake Engine Power

### 1.7.2 Characteristic of Brake Specific Fuel Consumption Characteristics of various fuels (Benchmark fuels and different biogas)

The highest brake specific fuel consumption rates of the engine are run with purified biogas at 1.919 kg/kW-h of cow-swine manure mixtures for high load throttle position and 2.549 kg/kW-h of cow manure for Low Load throttle position. The BSFC of purified various biogas consume more fuel than benchmark fuels because LPG is 8% more efficient on SI engines (Smith et al., 1997) due to its higher-octane number, auto ignition temperature, great flame velocity and wider flammability limits that make the LPG a better fuel in spark-ignition engine (Erkus et al., 2013). At the same time, gasoline with 2T engine oil operates on its original fueling system with natural aspiration on the engine. In comparison to biogas,

the higher the percentage of purified biogas in the mixture, the higher brake specific fuel consumption due to the gaseous state of biogas that attributed incomplete combustion due to suction of biogas-air mixture instead of air in the inlet manifold (Prabhu et al., 2018).

**Figure 15. Characteristic of BSFC**

**3.3. Characteristic of Brake Thermal Efficiency Characteristics of various fuels (Benchmark fuels and different biogas)**

The brake thermal efficiency is used to evaluate the engine that converts the heat input of the fuel into mechanical energy. In both throttling positions, the swine manure biogas at 18.45% yields the highest brake thermal efficiency compared to benchmark fuels at 1.41% of LPG fuel. This is due to the high methane concentration of purified biogas, the BTE on both throttling opening positions are higher than benchmark fuels because biogas has a lower thermal value than gasoline. Furthermore, LPG has a lower thermal value than gasoline in terms of mass but, in terms of volume, the lower thermal value of gasoline is greater than LPG. This indicates that more fuel must be required to achieve the same movement. As a result, LPG and biogas have higher BSFC values than gasoline. Since the fuel consumption rate are kept constant at minimal consumption and the calorific value of biogas are kept lean, BTE that depends on combustion quality increases due to increased frictional losses (Reddy et al., 2016).

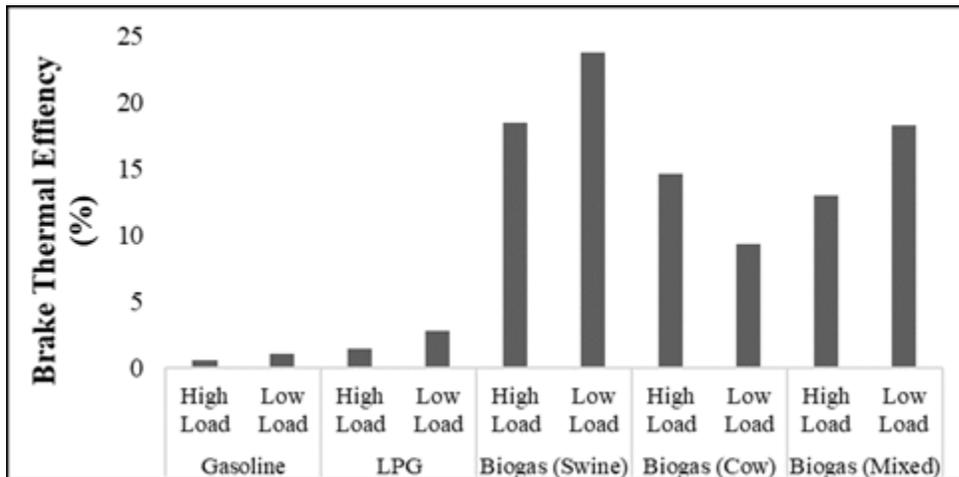


Figure 16. Characteristic of Brake Thermal Efficiency

**Conclusion and Recommendations**

The engine performance characteristic of a 2–stroke spark-ignition engine was compared with various biogas (cow manure, swine manure, mixed cow-swine manure) and benchmark fuels (LPG and Gasoline with 2T engine oil) under different throttling opening positions (High load throttle and Low Load throttle opening positions) for comparative characteristics. The following conclusion are derived: (1) The benchmark fuels at both throttling opening positions, the LPG achieved the highest parameters of 548.368 Watts of brake engine power, 14,499 rpm for brake engine speed, 0.003 kg/kW-h for BSFC and 1.41% for brake thermal efficiency. Because gaseous fuel for SI engines has a higher self-ignition temperature, resulting an increased engine parameter; (2) From the three-manure used to run in a 2–stroke gasoline engine, the swine manure biogas achieved the highest engine parameters at 761.485 Watts, 10,443 rpm for brake engine speed, 1.431 kg/kW-h for BSFC and 18.46% for brake thermal efficiency. The conversion from gasoline to purified biogas fueled engine is successful and able to run in a 2–stroke spark ignition engine for small scale operation; (3) The engine ran with stability and was able to achieve the engine parameters that were required in this study for comparative of benchmark fuels to various biogas in both

throttling opening positions (Low load throttle and High load Throttle). From the various fuels compared, the biogas almost acquired the highest engine parameters fueled in 2-stroke spark-ignition engine in terms of brake power and brake thermal efficiency compared with Liquified Petroleum Gas attained the highest brake engine speed at all throttling opening position. Biogas can be a viable option as an alternative fuel for 2-stroke spark-ignition engines and spark-ignition engines in rural areas as the performance of the engine using biogas is considerably identical and compared to gasoline fuels and LPG. It is recommended that future studies on different pressure from optimal operating pressure to lower pressure for all fuels to be tested in 2-stroke spark ignition engine at different throttling opening positions. And to get the exhaust emission composition of the engine fueled by different fuels at different throttling positions. Also, future studies on biogas fuel compression for commercial purposes.

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## **A New Opportunity for Effective Standardized Facilities Management System for SUCs utilizing QR Code Technology**

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*Abstract - The study covered the following: elaboration concerning the existing processes used in the facility management of SUCs; a proposed standardized process for facility management using Quick Response Codes; the level of assessments, agreement, and acceptance on the inclusion of QR codes and cloud computing for university facility management, and a system prototype.*

*The purpose of the study is to create a system prototype that follows a standardized process and implements the QR code system for timely updates and to determine the level of acceptance for the proposed process and its features. The study intends to provide a solution to the difficulty that Philippine SUCs are currently facing. With research and development, an answer shall be produced in the form of a system prototype that integrates with technologies that shall ease the strain that decentralized and paper-based management brings.*

*Keywords - Facilities; Prototype; QR Code; SUCs; Web-based*

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### **Introduction**

QR codes are 2-dimensional codes which contain data such as links, images, texts, or IDs that may be of different data types – even plain texts. It has a fairly larger data size capacity than that of barcodes and instead of using it for asset management only, QR codes may also be used for advertisement, even party games, reservations, or any other activity.

As mentioned, QR codes can be used in asset management. The essential question is why should one use these? The answer is that QR codes are easy-to-use, quicker, and versatile. Not only can these codes be designed to fit a company's color or logo if the company wishes to, but these are also flexible and adaptable.

With the involvement of QR code scanning for asset management and the implementation of cloud computing for computer transactions in mind, information management systems, facilities management systems specifically, may come to mind. The scanning process of QR codes in mind, it has been said that Information Technology has taken every aspect of the humans' daily lives from craft to leisure and even culture (Olmo, 2015) and one of the gifts of IT is the mobile devices. Mobile devices are close to being limitless at the present time and one of the things it can be is a scanner; particularly, a barcode scanner. Instead of buying a barcode scanner which is more costly and limited, one can use his/her mobile phone to scan a QR code and see its value if the need arises.

The Philippine State Universities and Colleges (SUCs) such as PNU, PUP, and CatSU have systems to manage their facilities and allow both insiders and outsiders to reserve these facilities. In this study, the researcher referred to PNU as SUC1, PUP as SUC2, and CatSU as SUC3.

SUC1 uses a semi-automated facility reservation system. SUC2 and SUC3 uses a paper-based facility management system. Although it delivers what it has to deliver – that is to allow reservations –, based on the interviews conducted, there are gaps and difficulties such as: decentralization, untimely management and tracking, and untidy organization.

The decentralization of the SUCs processes led to the researcher on the problems to be sought like of: untimely management and tracking, and untidy organization. Using the concepts exposed earlier, the QR code system, cloud computing, and the SUCs, the researcher conceptualized a solution that will

help ease these problems. Through benchmarking, the researcher looked for a pattern in the processes used by the aforementioned SUCs to create a standardized process for facilities management systems that assists in keeping requests organized, which are on the cloud to support centralization, and with the implementation of the QR code system, a timely clock-in and clock-out of the facilities borrowed shall be recorded.

It is the goal of this to create a system prototype that follows a standardized process and implements the QR code system for timely updates and to determine the level of acceptance for the proposed process and its features.

## Methodology

The researcher used the form of investigation by using the descriptive-developmental method. SUC3 is the university that has been chosen for the pilot testing of the solution. This university is located in the Bicol Region of Luzon where it is frequently hit by typhoons. With this in mind, the use of a Business Contingency Plan (BCP) is needed to support the operation and performance of system in case of there is no electricity and/or there are problems with internet services. As mentioned, the study used the descriptive-developmental method of research in achieving the requirements needed in the investigation of the study. With the aid of this method, the researcher was able to make the analysis and the development of the system.

Developmental method was used since the study is looking for a better solution to an existing traditional system. It is appropriate to the study since this method includes a fact-finding way of acquiring data with adequate interpretation. It also enables the researcher to analyze and learn the different transactions done.

## Results and Discussions

The result of the study is presented in the in five parts. The first part presents the existing facilities management processes for State Universities and Colleges (SUCs). The second part presents the proposed standard process that is the QR-Based Solution. The third part gives the level of assessment of the respondents in having a standard automated process for a QR based Facilities Management for State Universities and Colleges. The fourth part describes the respondents' level of agreement on the benefits of adopting QR codes in monitoring the facilities of a University. The fifth part looks into the respondents' level of acceptance on the inclusion of the different functionality features for a University Facility Management that has provisions for public use.

### 1. Existing Process of the three (3) SUCs

The existing process of SUC1 has different ways of treating different categories of activities; the categories of activities are: Faculty-initiated Activities, Student-initiated Activities, and Outsider-initiated Activities.

The Faculty-initiated Activities are used to categorize the University offices who wish to use the venues for special events and programs. Student-initiated Activities are from the student organizations/classes; and Outsider-initiated Activities are for the outsiders who wish to use the venues for their activities. Per initial gathering of data, the researcher learned that SUC1 prioritizes outsiders' requests for it brings the university/college bigger income compared to that of student and/or faculty-initiated activities. Say there was a student/faculty-initiated activity which was booked prior to the event of the outsiders requests, the former activity will be moved to other venues or dates.

SUC2 has no centralized procedure being implemented on the use of the facilities. SUC2 has three major procedures in the use or in requesting facilities, namely: SUC2 Oval, vehicles, and other facilities such as: Audio Visual Room (NLRC), CM Recto, Bulwagan Balagtas, Bulwagan Bonifacio, Freedom Park,

and Amphitheatre under the supervision of CDMO (Campus Development and Maintenance Office). Among the three SUCs, the case of SUC2 is different due to the fact that its oval facility has sub-facilities; the sub-facilities include a gymnasium, and an open court which also contains several facilities inside it such as 2 volleyball courts, 2 basketball courts, lawn tennis, and swimming pool which are all under the supervision of the College of Kinetics.

The SUC3 has a similar process when it comes to facility management with SUC2, both have decentralized procedures being implemented and both uses a manual process in booking requests to returns. Other similarities with regards to the process with the SUC2, which the priority of use, shall be for instructional, academic, and other related activities. Handling and supervision of vehicle request are under Motorpool department, whereas, several venues that are under the management of the Supply Office and other facilities are with the Supervising Administrative Office (SAO).

## 2. Standard Process with QR based solution

On the proposed standard process with QR-based solution, there are four main actors, the requestor, the system itself, staff/checker and the approver/s. The requestor may visit the website to check the availability of the facilities on the e-calendar. After checking the availability of the facilities, the requestor may fill up and submit the form. Upon submission of the requestor's information online, he/she will receive a confirmation code (a 6 character-code that is a combination of alphanumeric characters); the system will notify the approver/s via email.

For the evaluation of the reservation, there will be a set of approvers - depending on the type of requestor, whether he is an outsider or from the academe/teaching or administrative /non-teaching group – that the reservation will be routed to. The result of evaluations and the round-the-clock tracking of the request will be seen by the requestor online. There is an allotted time for each request, as stated in the Republic Act No. 9485 “An Act to Improve Efficiency in the Delivery of Government Service to the Public by Reducing Bureaucratic Red Tape, Preventing Graft and Corruption, and Providing Penalties Therefor”. This act promotes integrity, accountability, proper management of public affairs and public property as well as to establish effective practices aimed at the prevention of graft and corruption in government. That if all applications and/or requests submitted shall be acted upon by the assigned officer or employee during the period stated in the Citizen's Charter which shall not be longer than five (5) working days in the case of simple transactions and ten (10) working days in the case of complex transactions from the date the request or application was received.

Once the final signatory/approver approved the request, an email will be sent to the requestor's email account. Notifying the requestor that the facility/ies requested is ready for claiming. Other than the approval process, the final approver also has the authority to close reservations upon or after the end date has been reached.

Upon claiming, the requestor shall bring a proof of identity and the reservation code (written in paper, saved as note on a mobile phone, or memorized). The Staff/Checker shall enter the reservation code and evaluate. Once matched, the Staff/Checker may select the facility to claim and set its status to claimed/unavailable.

After the event, the requestor shall return the facility's key, on which the QR code is attached. The QR-codes shall be used in system for asset management and not the reservations per se. For facilities that do not require keys such as the oval, open field courts, pool and alike are still covered from this requirement. Thus, in replacement for the keys requirement, issuance of the QR code tag attached to cards will be made.

For the return of the facilities, the Staff/Checker shall scan the QR code tags and input the remarks and findings on the return status (such as: returned, damaged and lost) based on the ocular inspection.

This procedure can be seen in Figure 1 Proposed Standard FRS – Reserve and Approve and Figure 2, – Proposed Standard FRS – Claim and Return

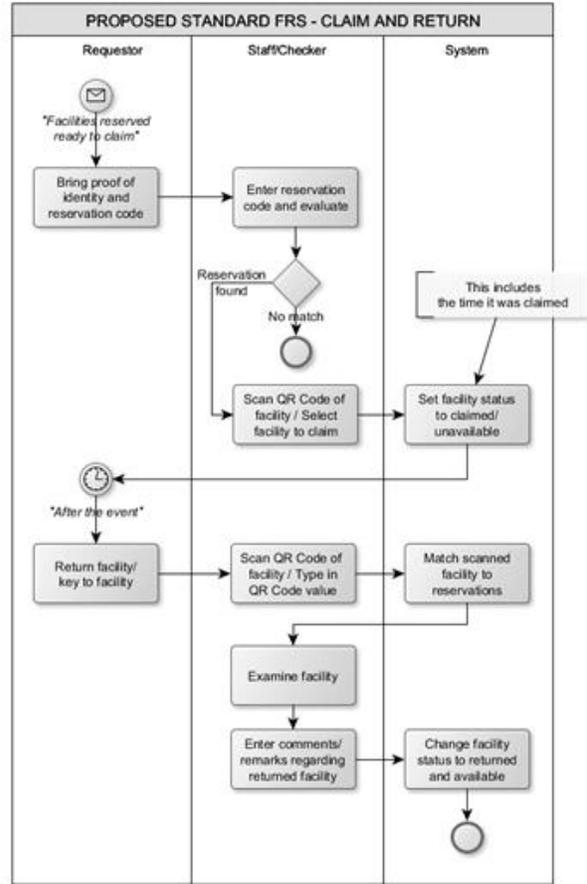
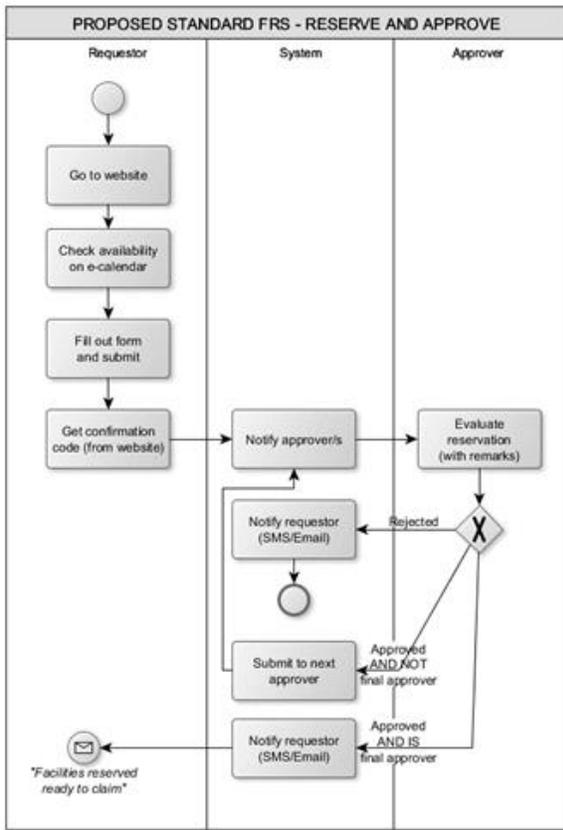


Figure 1  
 Proposed Standard FRS – Reserve and Approve  
 Return

Figure 2  
 Proposed Standard FRS – Claim and  
 Return

The figure on the next page shows the use-cases of the proposed facility management system with standardized process.

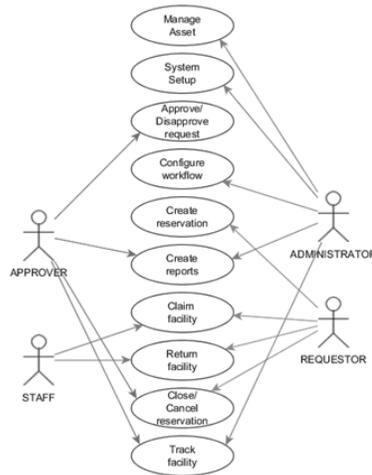


Figure 3 Use-Case Diagram for the Proposed System

As shown above, the Administrator has five use-cases that include asset management, system setup, workflow configuration, reports generation, and facility/asset tracking.

Same with the Administrator, the Approver has the same ability to view/track facilities and other SUC's assets but unlike the Administrator, the Approver has a bigger influence in request approval for he/she has the final say and/or the authority to approve/disapprove request/s; including the power to close or cancel facility reservations.

Once a request has been approved, the claiming and return of facilities will be under the supervision of the Staff/Checker. He/she has the authority to tag/put the status or findings of the borrowed facility/ties during inspection. The Staff/Checker may state the following notations: returned, damaged and lost.

3. Respondents' Level of Assessment in Having a Standard Automated Process for a QR Based Facilities Management for State Universities and Colleges

The respondents' assessment on the effects in having a standard automated process for a QR based Facilities Management for State Universities and Colleges is very strong.

The details of the interpretation are presented in detail in table 1 with its mean, interpretation, and fractional ranking.

**Table 1**  
**Respondents' Level of Assessment in having a standard automated process for a QR based Facilities Management for State Universities and Colleges**

STATEMENT	MEAN RESPONSE	INTERPRETATION	RANK
1. With the proposed automated system, transactions/requests for the use of the facilities/services are captured, recorded, and traced electronically; hence, this will help in promoting, transparency in the government.	3.67	Very Strong	7.5
2. With the use of the automated system, this would expedite and streamline processes.	3.71	Very Strong	5.5
3. Such automation for facilities/services, requests would be an aid for the decision-making process.	3.53	Very Strong	10
4. Such strong system will increase the productivity of the users and economy on the part of the institution since this would be a paperless transaction.	3.73	Very Strong	3.5
5. The system will become a breakthrough in the advancement of the way transactions/requests are forwarded and monitored; that will eliminate traditional routing slip.	3.73	Very Strong	3.5
6. The proposed automated system encourages digital literacy among the users.	3.71	Very Strong	5.5
7. The proposed automated system will need support of the administration in terms of finance and	3.67	Very Strong	7.5

preparation/training on the part of the users for it to be implemented and utilized successfully.			
8. Administrative problems <i>mañana habit</i> , <i>ningas cogon</i> or other work attitude excuses of the government employees will be addressed or minimized since tracking of procedures/requests will be made on-time.	3.56	Very Strong	9
9. The proposed automated system supports a paperless environment, reducing untidiness in the workspace and it also help avoid the misuse/simple corruption of resources in the workspace.	3.76	Very Strong	1
10. The proposed automated system encourages the government to allot reasonable budget for electronic/cloud-based procedures and advancement for employees.	3.75	Very Strong	2
<b>OVERALL MEAN</b>	<b>3.68</b>	<b>Very Strong</b>	

4. Respondents' Level of Agreement on the benefits of adopting QR codes in monitoring the facilities of a University

The respondents' agreement on the benefits of adopting QR codes in monitoring the facilities of a University is presented in table 2 with its mean, interpretation and fractional ranking.

As seen in the table, the respondents strongly agreed that the adoption of QR codes in monitoring the facilities of a University will be beneficial based on the obtained overall mean assessment of 3.64.

The QR codes' ability to store a variety of data ranked first, has a mean of 3.73, respondents strongly agreed that it will be beneficial.

The QR codes including an Error Correction Level (ECL) that enables "damaged" codes to still be scanned ranked equal with the QR codes' versatility to be customized artistically at rank 2.5 with the mean of 3.64, interpreted as strongly agree.

The tools to generate and read 2D barcodes such as QR codes being free and management tools being available to track scanning analytics tied at rank 4.5 with a mean of 3.62 and interpreted as strongly agree.

Lastly, "QR codes can be placed in and on nearly any location" and "mobile barcode scanning is on the rise" ranked equal at 6.5 with a mean of 3.60 and interpreted as strongly agree.

The respondents strongly agreed on the benefits of QR codes and the items that have "Strongly agree" as interpretations are the same with the ones discussed as the benefits of QR code in articles and studies from Probst et al. (2012), Patel (2012), Johnson (2011), Tolliver-Walker (2012), Carmine (2012), Küçükaltan et al. (2014) such as: data types, low cost maintaining, tracking and identification, interactive, and branding approach.

All the items were marked as "Strongly Agree" which can be interpreted as: QR codes are highly beneficial for facilities monitoring. The QR code's feature to store a variety of data ranked first because of all the items in the list, this is the most obvious weakness of the current facilities management systems – being able to store a variety of data in facility tags.

**Table 2**  
**Respondents' Level of Agreement on the benefits of adopting QR codes in monitoring the facilities of a university**

STATEMENT	MEAN RESPONSE	INTERPRETATION	RANK
1. Can Store a Variety of Data	3.73	Strongly Agree	1
2. Can be Placed in and on Nearly Any Location	3.60	Strongly Agree	6.5
3. Tools to Generate and Read 2D Barcodes such as QR codes are <i>Free</i>	3.62	Strongly Agree	4.5
4. Mobile Barcode Scanning is on the Rise	3.60	Strongly Agree	6.5
5. Management Tools are Available to Track Scanning Analytics	3.62	Strongly Agree	4.5
6. QR codes include an Error Correction Level (ECL) that enables "damaged" codes to still be scanned.	3.64	Strongly Agree	2.5
7. QR codes can be Customized Artistically	3.64	Strongly Agree	2.5
<b>OVERALL MEAN</b>	<b>3.64</b>	<b>Strongly Agree</b>	

5. Respondents' Level of Acceptance on the Inclusion of the Different Functionality Features for a University Facility Management that has Provisions for Public Use

The respondents' level of acceptance on the inclusion of the different functionality features for a University Facility Management that has provisions for public use is presented in table 9 with its mean, interpretation, and fractional ranking.

As seen in the table, the respondents found the inclusion of the different functionality features for a University Facility Management that has provisions for public use highly acceptable; this is revealed by the obtained overall mean assessment of 3.76.

**Table 3**  
**Respondents' Level of Acceptance on the inclusion of the different functionality features for a University Facility Management that has provisions for public use**

STATEMENT	MEAN RESPONSE	INTERPRETATION	RANK
1. It can upload written electronic request from the requestor.	3.73	Highly Acceptable	9.5
2. It can send written requests to the recommending and approval signatories.	3.73	Highly Acceptable	9.5
3. It can let the requestor view the availability of the venue/service requested through the calendar.	3.71	Highly Acceptable	11
4. It can update booked requests and delete cancelled reservations on the calendar.	3.67	Highly Acceptable	13
5. It can update the requestor's request status or update on real time.	3.78	Highly Acceptable	5
6. It can upload written electronic request from the requestor.	3.73	Highly Acceptable	9.5

7. It can send written requests to the recommending and approval signatories.	3.73	Highly Acceptable	9.5
8. It can show remarks or causes of delay on the approval status.	3.75	Highly Acceptable	7.5
9. It can display signatories' action on the request.	3.75	Highly Acceptable	7.5
10. It can print and view of transactions any time.	3.76	Highly Acceptable	6
11. Standardized, organized and indexed storage facility management request.	3.84	Highly Acceptable	1.5
12. Interconnectivity/centralized information system for the facility request.	3.84	Highly Acceptable	1.5
13. Centralized and secured records keeping of requests and transactions.	3.80	Highly Acceptable	4
14. There is a separate account and scope/module for administrator, request signatories and user/requestors promoting control in access and system security.	3.82	Highly Acceptable	3
<b>OVERALL MEAN</b>	<b>3.76</b>	<b>Highly Acceptable</b>	

## Conclusion and Recommendations

The study has drawn the following conclusions based on the findings plotted by the researcher:

Based on the benchmarking conducted, it can be concluded that with the semi-automated process used by SUC1 and the manual process used by SUC2 and SUC3, challenges specified in the study are truly experienced by the organizations; that being decentralization, strenuous routing of signatories, untimely and untidy management and tracking of facilities request.

It is concluded that the developed Facilities Management Solution is functional and reliable. It supports a paperless environment which may minimize simple acts of corruption in the workspace like the misuse of resources and time. With this said, it can further minimize corruption because of the solutions turn-around time monitoring for approval feature wherein requestors can transparently view the time consumed by approvers during the approval process. Finally, it supports/answers the general problem such as decentralized paper-based management.

The researcher found that adopting QR Codes for monitoring facilities of a university is very beneficial. It is found that the capability of storing variety of data is the most beneficial, and capability of being placed in and on nearly any location is the least beneficial.

Overall, the researcher found that the inclusion of different functionality features for a university facility management is highly acceptable. It has been concluded that having a standardized, organized and indexed storage facility management request and a centralized information system of facility request is most acceptable amongst the features.

The researcher concluded that with the inclusion of highly recommended features in the current process, a more robust automated and more streamlined Facilities Management of State Universities and Colleges will be created.

The following recommendations are offered:

It is suggested that the system should be deployed in a cloud-based environment in order to establish a more accessible and centralized information system.

It is recommended that the solution is used constantly once implemented in order to create a sense of familiarity. With this, the user will be able to use it with ease and through time and correct usage, the solution will be able to aid the entire organization in terms of productivity, economy, and even aid in creating better decisions for the area of facilities management.

It is recommended that the future researchers and developers exploit the QR code system and put its other capabilities to use in facilities management in a manner that it will be usable and beneficial.

It is suggested that other features will be included in the system or allow the integration of other sub-systems like that of billing or the integration of mobile applications to make the FMS' functionalities more robust.

It is suggested that other than the incorporation of predictive maintenance feature, the incorporation of SMS notification to the requestors to support a quicker and easier notification process be added as well.

The use of Business Contingency Plan (BCP) is highly advised to support the operation and performance of system in case of there is no electricity and/or there are problems with internet services (such as cloud storage troubles; and slow bandwidth rate) like of the case of SUC3.

The use of webcam of scanning is also an alternative. However, for more stable and effective scanning, the use of a 2D barcode scanner is better, though it is more expensive.

There should be close monitoring of facilities, venues and equipment for tagging of remarks/findings after return, to attain the degree of accuracy in its real time.

## **Acknowledgement**

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### Ultrasonic Blind Stick

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*Abstract - This developmental research aimed to design, develop, and test an Ultrasonic Blind Stick to help visually impaired people. It contained the technical features: obstacle detection and multiple sensors utilization. It also aimed to test its quality in terms of stability, functionality, reliability, cost-effectiveness, and sensory; and to develop a user's manual. The respondents of the study consisted of ten electronics engineers, fifteen engineering students, and five visually impaired persons from the Home for the Blind Community. The data gathering process began with a written request to the City Government Office of Bacolod through the Department of Social Services & Development (DSSD) which sought the approval to conduct the study at the Home for the Blind, and the Dean of the College of Engineering to conduct the study in the institution. The study utilized a researchers'-made research instrument, which recorded a validity rating of 4.33 and a reliability rating of 0.95, making it valid and reliable. Results revealed that the distance of the prototype from the obstacle should be between 0.1 and 0.7 meters to provide accurate detection. The water sensor buzzes if there is a puddle of water, and as the distance of the prototype from an obstacle decrease, the frequency of tone produced by the buzzer increases. The quality dimensions: functionality, reliability, and sensory, were interpreted as excellent according to the evaluation of visually impaired people; all quality dimensions from the professionals; and only cost-effectiveness was interpreted as very satisfactory based on the evaluation of the students.*

*Keywords - Ultrasonic Blind Stick, visually impaired people; Home for the Blind Community; Department of Social Services & Development; Quality dimensions*

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### Introduction

Vision is the most important part of human physiology as 83% of information human being gets from the environment is via sight (Pangavhane, Patil, More, Kulkarni, 2016). The conventional and oldest mobility aids for persons with visual impairments are characterized by many limitations. World Health Organization (2018) stated that globally it is estimated that approximately 1.3 billion people live with some form of vision impairment. Over the years, the walking cane has been the most common tool that visually impaired people use to navigate and detect obstacles (Nowshin, Shadman, Joy, Aninda & Minhajul, 2017). Today's technology is improving daily aspects to provide a flexible and safe environment for visually impaired people.

Previous studies focused only on developing a smart walking stick using ultrasonic sensors and buzzers to aid visually impaired people to navigate, but so far, there have been few studies conducted which attempted to incorporate a water detector sensor and wireless remote. This prompted researchers to develop a new technology that would aid visually impaired people, a technology that is user-friendly and would enhance guidance to them.

This study aimed to provide an alternative to the traditional walking stick. The developed blind stick intends to provide accurate detection of objects and guide the visually impaired person accordingly. The blind stick was integrated with ultrasonic sensors along with a water detector sensor. The study utilized ultrasonic sensors to detect obstacles in three directions (front, right, and left) using ultrasonic waves and a water detector sensor to detect puddles of water. These sensors were installed on a cane, and a roller was installed on the cane to provide convenience for the visually impaired person. On sensing obstacles,

the sensor passes data to the microcontroller. The microcontroller then processes this data and checks if the obstacle is within the vicinity of the visually impaired person. Once an obstacle is detected, the buzzers would produce distinct tones for each direction (front, left, and right). Likewise, the frequency of tone would increase as the distance of the obstacle decreases. Moreover, a different buzzer would be triggered if puddles of water were detected and would produce a different tone. Furthermore, a wireless-based remote was also integrated to help visually impaired persons find their blind stick if they forget where they kept it. It is along with these premises that a study of this nature was conducted.

### Objectives of the Study

Generally, this study aimed to design, develop, and test an Ultrasonic Blind Stick.

Specifically, this study sought to:

1. Design and develop an Ultrasonic Blind Stick with the following technical features:
  - a. Obstacle detection; and
  - b. Multiple sensors utilization
2. Test the quality of the Ultrasonic Blind Stick in terms of:
  - a. Stability;
  - b. Functionality;
  - c. Reliability;
  - d. Cost Effectiveness; and
  - e. Sensory
3. Develop a user's manual

### Methodology

This quantitative study employed a developmental method of research to design, develop, and test an Ultrasonic Blind Stick. Similarly, this study emphasized the technical features: obstacle detection and multiple sensors utilization as the design criteria. This study has also employed the procedures: planning, designing, assembly, testing, and maintaining to ensure the successful designing, development, and testing of the prototype with excellent quality.

First, the planning stage began with deciding what electronic components and modules would be used for the security and power supply of the prototype. This stage also included the drafting of the possible physical layout of the prototype. Second, the designing stage involved the creation of the general layout of the prototype, intense analysis of the design conditions and assumptions, identification of the possible key parameters, comparison, and analysis of different materials suited for the prototype, block diagram of the study, the parts and function of the prototype, and the flowchart of the prototype.

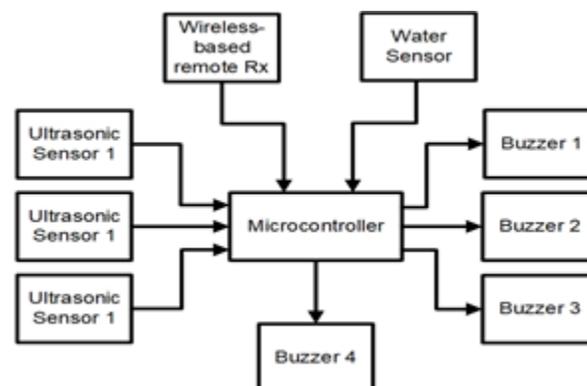


Figure 1. Block Diagram of the Study

As shown in figure 1, the microcontroller was used for controlling the sensors. Waterproof ultrasonic sensors were utilized as a proximity sensor to detect obstacles which would then assist the visually impaired person in navigating. Likewise, the water sensor was utilized to notify the visually impaired person if there is a puddle of water near the visually impaired person.

Third, the assembly stage emphasized the preparation of the tools, equipment, and materials that were utilized in the development, construction, and installation of the components of the prototype. Fourth, the testing stage focused on the continuity of electrical connections, testing for component failures, and initial quality testing. And fifth, maintaining stage involved the periodic checking of the connections of components of the prototype.

### **Evaluation Procedure and Data Analysis**

The evaluation process began with a written request to the City Government Office of Bacolod through the Department of Social Services & Development (DSSD) which sought the approval to conduct the study at the Home for the Blind and the Dean of the College of Engineering to conduct the study in the university. Moreover, the researchers conformed to the ethical requirements of research during the conduct of the study.

The mean was utilized to assess the quality of the prototype. There were five scales to interpret the quality of the prototype. As such, a mean scale of 4.21 – 5.00 was interpreted as Excellent; 3.41 – 4.20 as Very Satisfactory; 2.61 – 3.40 as Satisfactory; 1.81 – 2.60 as Poor; and 1.00 – 1.80 as Very Poor.

### **Research Instrument, Validity, and Reliability**

The researchers developed a researchers'-made survey questionnaire. The survey questionnaire was a 25-item instrument, which employed a 5-point Likert scale to the stability, functionality, reliability, cost-effectiveness, and sensory of the prototype, wherein 5 = Very Agreeable, 4 = Agreeable, 3 = Fair, 2 = Not Agreeable, and 1 = Not Very Agreeable. Moreover, the contents of the instrument underwent content validation by a panel of evaluators comprising experts in the field of Electronics Engineering and the English language. With a validity rating of 4.33 over 5.00 using the criteria set forth by Carter V. Good and Douglas B. Scates, it was declared valid. Similarly, Cronbach alpha was utilized to determine the reliability of the instrument. Test value established an alpha value of 0.93, making the researchers'-made research instrument very reliable.

### **Respondents of the Study**

The respondents of the study consisted of ten (10) experts in the field of Electronics or any other related fields, fifteen (15) Engineering students, and five (5) visually impaired persons from the Home for the Blind Community. Also, the instrument was administered for three (3) weeks. Moreover, the researchers utilized convenience sampling to provide easy and fast data collection.

### **Results and Discussions**

The first objective of the study was to design and develop an Ultrasonic Blind Stick with the technical features – obstacle detection and multiple sensors utilization.

**Table 1. Functionality Test of the Prototype**

Ultrasonic Sensor 1 Detected?	Ultrasonic Sensor 2 Detected?	Ultrasonic Sensor 3 Detected?	Distance 1	Distance 2	Distance 3	Buzzer 1	Buzzer 2	Buzzer 3
✓	✗	✗	<0.7m	>0.7m	>0.7m	✓	✗	✗
✗	✓	✗	>0.7m	<0.7m	>0.7m	✗	✓	✗
✗	✗	✓	>0.7m	>0.7m	<0.7m	✗	✗	✓
✓	✓	✗	<0.7m	<0.7m	>0.7m	✓(1 <sup>st</sup> )	✓(2 <sup>nd</sup> )	✗
✗	✓	✓	>0.7m	<0.7m	<0.7m	✗	✓(1 <sup>st</sup> )	✓(2 <sup>nd</sup> )
✓	✗	✓	<0.7m	>0.7m	<0.7m	✓(1 <sup>st</sup> )	✗	✓(2 <sup>nd</sup> )
✓	✓	✓	<0.7m	<0.7m	<0.7m	✓(1 <sup>st</sup> )	✓(2 <sup>nd</sup> )	✓(3 <sup>rd</sup> )

Table 1 shows the functionality of the prototype, where the ultrasonic sensors were assessed if it would detect an obstacle (front, left, right) within the specified distance and if the buzzer will trigger if an obstacle was detected. Results revealed that the ultrasonic could only detect an obstacle for fewer than 0.7 meters. Likewise, the buzzer would only be triggered if an obstacle was detected. The buzzers would trigger in a succeeding manner if there were multiple obstacles detected. And as the distance of the prototype from an obstacle decrease, the frequency of tone produced by the buzzers increases.

**Table 2. Functionality Test of the Water Sensor**

	Surface	Detected	Beeped
DRY	✓	✓	✗
WET	✓	✓	✓

As shown in table 2, the water sensor could detect an obstacle regardless of how dry or wet the surface was. However, the buzzer would only be triggered if the surface was wet. This implied that the buzzer would be triggered if there was a puddle of water on the surface, which then notifies the visually impaired person that the surface is wet. Results also revealed that as the distance of the prototype from a puddle of water decreases, the frequency of tone produced by the buzzer increases.

**Table 3. Loudness and Range Test of the Wireless Buzzer**

Is the button pressed?	Distance	Loudness (dB)
Yes	0m	79dBA
Yes	1m	74dBA
Yes	2m	70dBA
Yes	3m	66dBA
Yes	4m	64dBA

Table 3 above presents the loudness and range test results of the wireless buzzer. Results revealed that as the distance of the wireless buzzer from the prototype decreases, the loudness of tone produced by the buzzer increases.

The second objective of the study was to test the quality of the Ultrasonic Blind Stick in terms of stability, functionality, reliability, cost-effectiveness, and sensory. The prototype was evaluated by experts in the field of electronics engineering or any other related fields, engineering students, and visually impaired persons from the Home for the Blind Community based on the research instrument developed by the researchers.

**Table 4. Evaluation Results from Professionals**

Quality Dimensions	Mean	Verbal Interpretation
Stability	4.58	Excellent
Functionality	4.50	Excellent
Reliability	4.46	Excellent
Cost-Effectiveness	4.42	Excellent
Sensory	4.44	Excellent
Legend:	4.21 – 5.00	Excellent (E)
	3.41 – 4.20	Very Satisfactory (VG)
	2.61 – 3.40	Satisfactory (G)
	1.81 – 2.60	Poor (P)
	1.00 – 1.80	Very Poor (VP)

Table 4 presents the evaluation results of the prototype from professionals. Results revealed that among the quality dimensions evaluated, stability was the strongest attribute of the prototype (M = 4.58), whereas its weakest attribute was cost-effectiveness (M = 4.42).

**Table 5. Evaluation Results from Engineering Students**

Quality Dimensions	Mean	Verbal Interpretation
Stability	4.29	Excellent
Functionality	4.31	Excellent
Reliability	4.37	Excellent
Cost-Effectiveness	3.88	Very Satisfactory
Sensory	4.55	Excellent
Legend:	4.21 – 5.00	Excellent (E)
	3.41 – 4.20	Very Satisfactory (VG)
	2.61 – 3.40	Satisfactory (G)
	1.81 – 2.60	Poor (P)
	1.00 – 1.80	Very Poor (VP)

Table 5 presents the evaluation results of the prototype from engineering students. Results revealed that among the quality dimensions evaluated, only cost-effectiveness registered an interpretation of "Very Satisfactory" (M = 3.88). It was also revealed that sensory was the strongest attribute of the prototype (M = 4.55).

**Table 6. Evaluation Results from Visually Impaired Persons**

Quality Dimensions	Mean	Verbal Interpretation
Stability	4.16	Very Satisfactory
Functionality	4.60	Excellent
Reliability	4.48	Excellent
Cost-Effectiveness	4.12	Very Satisfactory
Sensory	4.48	Excellent
Legend:	4.21 – 5.00	Excellent (E)
	3.41 – 4.20	Very Satisfactory (VG)
	2.61 – 3.40	Satisfactory (G)
	1.81 – 2.60	Poor (P)
	1.00 – 1.80	Very Poor (VP)

As shown in table 6, stability and cost-effectiveness registered an interpretation of "Very Satisfactory" (M = 4.16, M = 4.12). Results also revealed that functionality was the strongest attribute (M = 4.60), whereas its weakest attribute was cost-effectiveness (M = 4.12).

The third objective of the study was to develop the corresponding user's manual of the prototype. It was found out that the user's manual was user-friendly and easy to operate.

## Conclusion and Recommendations

Based on the findings of the study, the following conclusions were drawn.

1. The Ultrasonic Blind Stick was functional and operational, considering the technical features mentioned in the study.
2. The prototype encompassed all quality dimensions mentioned in the study.
3. The user's manual was user-friendly and easy to operate.

In view of the findings and conclusion of the study, the following recommendations were formulated.

Future researchers should conduct related studies on the unexplored and underexplored aspects of this study. Suggestions to future researchers for the present technical features include the utilization of long-distance and high sensitivity proximity sensors, incorporation of headphones so that the sound produced by the buzzers could still be heard in crowded places, incorporation of vibration sensors to effectively alarm the visually impaired if an obstacle is nearby.

Future researchers were also encouraged to include additional technical features like lightweight, retractable cane so that the prototype could effectively be utilized in uneven surfaces, incorporation of a fall-detection sensor so that family members of visually impaired persons would be alerted if they have been in an accident. Moreover, future researchers should concentrate on cost-effectiveness when they develop improvements in the study.

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## Early Prediction of Diabetes using ID3 Algorithm

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*Abstract - Diabetes is a very chronic disease that we should treat in an early stage. Predicting diabetes in an early stage can help us treat it well and improved treatment. Nowadays, a lot of research in diabetes done through data mining to help us predict and analyse through the help of each attribute and datasets. In this paper, the researcher manages to use the attributes and datasets as the training data and use ID3 algorithm to predict the result. The finding shows a strong relationship with other attribute used in this research. With regards to result, ages 31-40 and 41-50 most likely to have a diabetes. Another result says that delayed healing and sudden weight loss can be also a sign of a diabetic person. With this research, we can assist in decision making to our medical professionals in predicting the early signs of diabetes and can treat it in an early stage.*

*Keywords - Data Mining; Diabetes; ID3 Algorithm*

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## Introduction

Nowadays, there are increasing number of diabetes cases around the world. This type of diseases can affect your life, your lifestyle, and the way you manage your daily routine. A lot of people suffer from this chronic disease and there are increasing number of deaths in this case. With this kind of disease, there is a chance of suffering from blindness and delayed healing. A lot of funds also spent by individual and our government to fight this kind disease (Paterson and Mercer 2018) (Skyler et al. 2017). There is an increased amount of diabetes as statistics shown in the year 2013 that revealed around 382 million individuals had this ailment around the world (Tao, Shi, and Zhao 2015). It was the fifth leading cause of death in women and eight leading causes of death for both sexes in 2015. Higher income countries have a high probability of diabetes (Organization 2019). There are approximately 451 million adults in 2017 that were treated with diabetes worldwide. There will be a projected of 693 million patients with diabetes will be exist around the world in 2045, and there will be a half number of populations will be undiagnosed. In 2017, the government spent an approximately 850 million USD with diabetes patient (Cho et al. 2018). We have very limited research in biological data but as time goes by their will be a computation and statistical models to be used for analysis. Several healthcare organizations gathered data from their patients to be use in this study. There is a continuous development of new knowledge gathered from a data using data mining techniques. Data mining were used to extract knowledge from the data, and this could be used for decision making process that will help medical assistance (Diwani et al. 2013). Several data mining techniques were used to predict and analyse this disease and finding knowledge with biomedical data (Alam 2019) (Alam and Awan 2018).

There is a lot of challenge in diagnosing a diabetes, because some attributes need to be considered before analysing and predicting the result (Cobos 2018). The following attributes were considered by the author: (1) Age; (2) Gender; (3) Sudden Weight Loss; (4) Genital Thrush; (5) Visual Blurring; (6) Delayed Healing; (7) Alopecia; and (8) Obesity. These attributes may help in analysing and predicting early sign of diabetes (Dorcely et al. 2017). In this study, early prediction of diabetes can be done using different attributes and decision tree prediction data mining Iterative like Dichotomiser (ID3) algorithm.

## Methodology

### Dataset

The dataset used in this study, is taken from Kaggle were sample of datasets are available (Kaggle 2021). Using this dataset, we can predict a patient whether it has a diabetes or not, the researcher gathered a list of 520 records that will be use in this prediction. The list of attributes to be use are: (1) Age; (2) Gender;

(3) Sudden Weight Loss; (4) Genital Thrush; (5) Visual Blurring; (6) Delayed Healing; (7) Alopecia; and (8) Obesity (9) Result. Table 1 shows the detailed attributes.

**Attribute Explanation:**

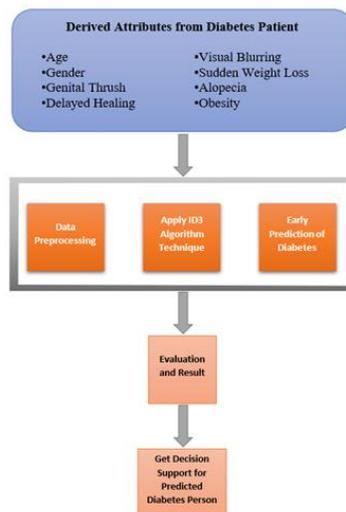
- 1 **Sudden Weight Loss** - unexplained weight loss can be a warning sign of diabetes (Pareek et al. 2018).
- 2 **Genital Thrush** - is a yeast infection (candida albicans) which tends to affect warm, moist areas of the body such as the vagina, penis, mouth and certain areas of skin (Morris 2021).
- 3 **Visual Blurring** - is a common sign of diabetes that isn't under control. When blood sugar levels are high for a long time, body water is pulled into the lens, causing it to swell (Lee, Chen, and Lai 2021).
- 4 **Delayed Healing** - wounds or sores that take more than a few weeks to heal might be infected and require medical treatment, and often indicate an underlying disease such as diabetes (Aikawa et al. 2017).
- 5 **Alopecia** - diabetes can interrupt process and slow down your hair growth. Having diabetes can also cause you to lose more hair than usual (Zhang and Nie 2021).
- 6 **Obesity** – obese people is more likely to have a diabetes (Ghada 2020).

**Table 1. Attributes**

Attribute	Range
Age	Age Bracket
Gender	Male/Female
Sudden Weight Loss	YES/NO
Genital Thrush	YES/NO
Visual Blurring	YES/NO
Delayed Healing	YES/NO
Alopecia	YES/NO
Obesity	YES/NO
Result	Positive/Negative

**Diabetes Prediction System Architecture**

Figure 1 shows the system architecture used for this study. It consists of three major phases such as (1) Data Pre-processing; (2) Apply ID3 Algorithm; and (3) Prediction.



**Figure 1. Diabetes Prediction System Architecture**

## I. Data Pre-processing

It is a process where the data needs to be checked for the values and or noisy and inconsistent data. If the quality of the data is not that good, then there is no quality result to be found. For us to achieve a good quality of results, we need to pre-process the data before using it. There is a list of process that we might need to consider before applying the ID3 algorithm, there the following: (1) Data Cleaning; (2) Data Reduction; and (3) Data Transformation (Benhar, Idri, and Fernández-Alemán 2018).

### 1.1. Data Cleaning

In this stage, we might need to fill up the missing values and remove the data that we don't need or the noisy data. Removing the noisy data can resolve a result of inconsistencies (Zainal Abidin, Ismail, and Emran 2018). In case of age, the researcher changes it to range so that we can predict a good quality of output.

### 1.2. Data Reduction

This process is used to reduce the number of attributes in a dataset that don't correspond to changes in our prediction. Sometimes, smaller volume of dataset produces the same or almost the same result with bigger volume (Liu and Motoda 2015).

### 1.3. Data Transformation

Data transformation is consisting of smoothing, normalization, and aggregation of data (Malley, Ramazzotti, and Wu 2016). Binning method was also used for smoothness of data like age that can be classified into 6 categories as shown in Table 2.

**Table 2. Binning of Age**

Age (years)	Age Bins
21	20-30
31	31-40
41	41-50
51	51-60
61	61-70
71	>70

A sample dataset of 70 individual will be used as our training data for the prediction, as shown in Figure 2.

Age	Gender	sudden weight loss	Genital thrush	visual blurring	delayed healing	Alopecia	Obesity	class
31-40	Male	No	No	No	Yes	Yes	Yes	Negative
31-40	Male	No	Yes	No	Yes	No	No	Positive
31-40	Male	No	Yes	No	Yes	Yes	No	Positive
31-40	Male	Yes	Yes	No	No	Yes	No	Negative
31-40	Male	No	Yes	No	Yes	No	Yes	Positive
31-40	Male	No	Yes	No	No	Yes	No	Positive
31-40	Male	No	No	No	Yes	Yes	No	Negative
31-40	Male	Yes	No	No	No	Yes	No	Positive
20-30	Female	Yes	No	No	Yes	No	No	Positive
20-30	Female	No	No	No	Yes	No	No	Positive
20-30	Female	No	No	Yes	No	Yes	No	Negative
41-50	Female	No	No	No	Yes	No	No	Negative
41-50	Female	No	No	Yes	Yes	No	No	Positive
41-50	Female	Yes	No	No	No	No	Yes	Positive
20-30	Female	No	No	Yes	No	No	No	Positive
41-50	Female	No	No	Yes	No	No	No	Negative
41-50	Female	Yes	No	Yes	Yes	No	No	Positive

20-30	Female	Yes	No	No	Yes	No	No	Positive
41-50	Female	Yes	Yes	No	Yes	Yes	Yes	Negative
>70	Male	Yes	Yes	Yes	Yes	No	No	Positive
>70	Female	Yes	Yes	Yes	No	Yes	No	Positive
>70	Male	Yes	No	No	Yes	Yes	No	Negative
41-50	Male	Yes	No	No	Yes	No	No	Positive
20-30	Male	No	Yes	Yes	Yes	Yes	No	Positive
51-60	Male	Yes	Yes	Yes	No	Yes	Yes	Positive
>70	Male	Yes	Yes	No	No	No	No	Negative
51-60	Female	Yes	Yes	Yes	Yes	No	No	Positive
41-50	Female	Yes	No	Yes	Yes	No	No	Positive
20-30	Female	Yes	No	No	No	No	No	Positive
31-40	Male	No	No	No	No	No	No	Negative
20-30	Male	No	No	No	No	No	No	Negative
61-70	Male	No	No	Yes	Yes	Yes	Yes	Positive
51-60	Male	No	No	No	No	No	No	Negative
51-60	Male	No	No	No	Yes	Yes	Yes	Negative
51-60	Male	Yes	Yes	No	Yes	Yes	No	Positive
41-50	Male	Yes	Yes	No	Yes	Yes	No	Negative
31-40	Male	No	Yes	No	No	No	No	Negative
31-40	Male	No	No	No	No	No	No	Positive
41-50	Male	No	No	No	No	No	No	Negative

Figure 2. Training Dataset

In figure 3, it shows a test dataset that will be use later for prediction.

Age	Gender	sudden weight loss	Genital thrush	visual blurring	delayed healing	Alopecia	Obesity	class
41-50	Male	Yes	No	No	Yes	Yes	Yes	
31-40	Male	No	No	No	Yes	No	No	
>70	Male	No	Yes	No	Yes	Yes	No	
51-60	Female	Yes	Yes	No	No	Yes	No	
41-50	Female	No	No	Yes	Yes	No	Yes	
31-40	Male	No	Yes	No	No	Yes	No	
31-40	Male	No	No	No	Yes	Yes	No	
31-40	Male	Yes	No	No	Yes	No	Yes	
41-50	Female	Yes	No	No	Yes	No	No	
20-30	Female	No	No	No	Yes	No	No	

Figure 3. Test Dataset

## II. Apply ID3 Algorithm

How does ID3 decide which attribute is the best? ID3 uses entropy and information gain to construct a decision tree (Mehrotra, Saxena, and Doohan 2018).

### Information Gain

The information gain is based on the decrease in entropy after a dataset is split on an attribute. Constructing a decision tree is all about finding attribute that returns the highest information gain. It tells us how important a given attribute of a set is. We will use this to decide of attributes in the nodes of a decision tree. To define Gain, we first borrow an idea from Information Theory – Entropy (Mehrotra et al. 2018).

### Entropy

A decision tree is built top-down from a root node and involves partitioning the data into subsets that contain instances with similar values (homogenous). ID3 algorithm uses entropy to calculate the

homogeneity of a sample. If the sample is completely homogeneous the entropy is zero and if the sample is an equally divided it has entropy of one (Mehrotra et al. 2018).

### Dataset

It is divided into training sets (used to build the model), and test sets (used to validate) (Rohman et al. 2019).

A Step-by-Step Process in Computing the Entropy and Information Gain.

### Formula:

Uses Shannon Entropy (Kaewrod and Jearanaitanakij 2017)

$$\text{Entropy}(S) = - P(p) \log_2(P(p)) - P(n) \log_2(P(n))$$

P(p) = proportion of positive training examples in S

P(n) = proportion of negative training examples in S

**Step 1: Compute for the Entropy of the entire data set.**

**Step 2: Compute for the Entropy and Gain for each attribute in the set.**

**Step 3: Select the attribute with the most Information Gain and use it as the root of the tree.**

**Rules:** (Kaewrod and Jearanaitanakij 2017)

1. A branch with entropy of 0 is a leaf node.
2. A branch with entropy more than 0 needs further splitting.
3. Construct the Decision Tree and repeat until all nodes are pure (Zero Entropy).
4. The ID3 algorithm is run recursively on the non-leaf branches, until all data is classified.

### III. Prediction

We are now going to evaluate all the attributes after it is computed based on ID3 algorithm. It will also display the predicted output for the historical data.

In figure 4, these are the files that are stored on our java folder where the program is stored. As you can see the files DiabetesDatasetTest.csv and DiabetesDatasetTrain.csv are what we are needing for the next process.

Name	Date modified	Type	Size
.classpath	20/11/2021 12:27 PM	CLASSPATH File	1 KB
.project	20/11/2021 12:27 PM	PROJECT File	1 KB
DiabetesDatasetTest.csv	20/11/2021 6:25 PM	Microsoft Excel C...	1 KB
DiabetesDatasetTrain.csv	20/11/2021 5:49 PM	Microsoft Excel C...	3 KB
ID3TreeNode.class	20/11/2021 12:37 PM	CLASS File	2 KB
ID3.class	20/11/2021 12:37 PM	CLASS File	8 KB
ID3.java	20/11/2021 12:37 PM	JAVA File	14 KB

**Figure 4. Java Folder**

Using java program, we can predict the result based on the training data and test data both have a CSV file. Just type the following syntax in command prompt for us to create another csv file for the predicted result as shown in figure 5.

```
java ID3 DiabetesDatasetTrain.csv DiabetesDatasetTest.csv > PredictionResult.csv
```

Figure 5. Command Prompt Syntax

After typing the syntax, another file will be created as our predicted output for the filename PredictionResult.csv as shown in figure 6.

Name	Date modified	Type	Size
.classpath	20/11/2021 12:27 PM	CLASSPATH File	1 KB
.project	20/11/2021 12:27 PM	PROJECT File	1 KB
DiabetesDatasetTest.csv	20/11/2021 6:25 PM	Microsoft Excel C...	1 KB
DiabetesDatasetTrain.csv	20/11/2021 5:49 PM	Microsoft Excel C...	3 KB
ID3TreeNode.class	20/11/2021 12:37 PM	CLASS File	2 KB
ID3.class	20/11/2021 12:37 PM	CLASS File	8 KB
ID3.java	20/11/2021 12:37 PM	JAVA File	14 KB
PredictionResult.csv	20/11/2021 6:12 PM	Microsoft Excel C...	4 KB

Figure 6. Added File PredictionResult.csv

Figure 7 shows the compressed ID3 result applied to our program and the prediction result based on the test dataset that we have applied to our program. Based on the result, there are 6 positive to a diabetes and 4 negative.

sudden weight loss=No	Genital thrush=No
i>¿Age=31-40	Gender=Male
Genital thrush=No	Class: Negative
Alopecia=Yes	Gender=Female
Class: Negative	Class: Negative
Alopecia=No	Genital thrush=Yes
Obesity=Yes	Class: Negative
Class: Negative	Obesity=No
Obesity=No	Class: Positive
delayed healing=Yes	i>¿Age=>70
Class: Negative	Class: Negative
delayed healing=No	i>¿Age=51-60
visual blurring=No	Class: Positive
Gender=Male	i>¿Age=61-70
Class: Negative	Class: Negative
Gender=Female	visual blurring=Yes
Class: Negative	Class: Positive
visual blurring=Yes	
Class: Negative	Positive
Genital thrush=Yes	Negative
delayed healing=Yes	
Class: Positive	Negative
delayed healing=No	
Alopecia=Yes	Negative
Class: Positive	
Alopecia=No	Positive
Class: Negative	
i>¿Age=20-30	Positive
delayed healing=Yes	
Genital thrush=No	Positive
Obesity=Yes	
Class: Negative	Positive
Obesity=No	Negative
Alopecia=Yes	
Class: Negative	Positive
Alopecia=No	
visual blurring=No	Positive
Gender=Male	
Class: Negative	Negative
Gender=Female	

Figure 7. Prediction Result

## Results and Discussions

In figure 8, using the historical data (training data) and test data, the researcher came up with the following prediction result: (1) Patient 1, 4, 5, 6, 8, and 9 will be most likely to have a diabetes based on the predicted result; (2) Ages 31-40 and 41-50 may have a diabetes; and (3) We can also consider that delayed healing and sudden weight loss can be a sign for person that has a diabetes.

Test Data									Prediction Result
Age	Gender	sudden weight loss	Genital thrush	visual blurring	delayed healing	Alopecia	Obesity	class	
41-50	Male	Yes	No	No	Yes	Yes	Yes		Positive
31-40	Male	No	No	No	Yes	No	No		Negative
>70	Male	No	Yes	No	Yes	Yes	No		Negative
51-60	Female	Yes	Yes	No	No	Yes	No		Positive
41-50	Female	No	No	Yes	Yes	No	Yes		Positive
31-40	Male	No	Yes	No	No	Yes	No		Positive
31-40	Male	No	No	No	Yes	Yes	No		Positive
31-40	Male	Yes	No	No	Yes	No	Yes		Positive
41-50	Female	Yes	No	No	Yes	No	No		Positive
20-30	Female	No	No	No	Yes	No	No		Negative

Figure 8. Test Data and Prediction Result

## Conclusion and Recommendations

The researcher provided very good research in combining data mining technique in predicting early sign of diabetes. ID3 algorithm was used to analyze and predict the result using the given attributes and several records that had been used as a training data. The medical professional can also benefit with this research to help them in their decision making. With regards to result, ages 31-40 and 41-50 most likely to have a diabetes. Another result says that delayed healing and sudden weight loss can be also a sign of a diabetic person.

Due to lack of time, the researcher would like to recommend that this study would have a good application for easy data analysis and prediction.

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## **File Encryption and Decryption using Blowfish Algorithm in Securing School Records**

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*Abstract - Uploading and storing files via cloud storage can be a good strategy especially if you are using this with your important files. Sharing cloud storage with different person can ease the problem in providing all the needed files to everyone. But this can bring some problem in concern to the privacy of each file being shared with others. So, this paper addresses the current problem through a file encryption/decryption using blowfish algorithm to secure the file before this can be uploaded on the cloud storage that was shared with others. Using the application, the file is being encrypted with password security before it can be uploaded on the cloud storage. From the cloud storage, the file needs to download and using the application to decrypt the file using the same password and the file is now readable.*

*Keywords - Blowfish Algorithm, Cryptography, Cloud Storage*

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### **Introduction**

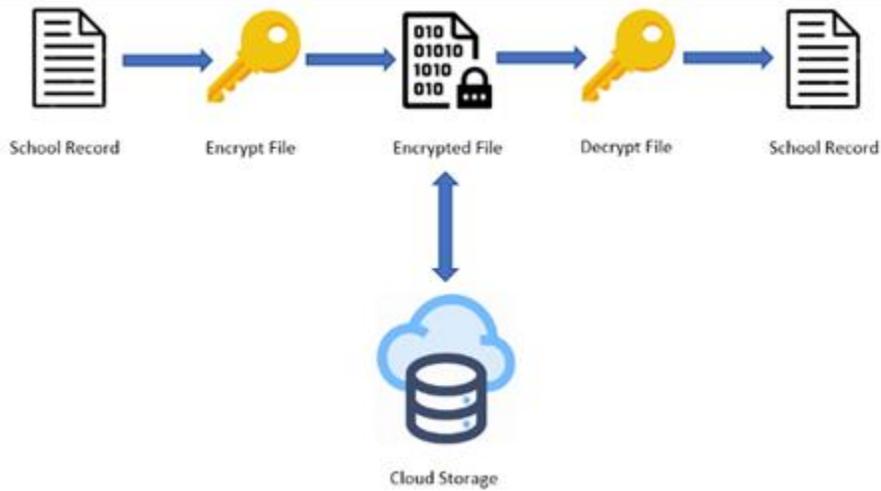
Data can be a precious and useful to groups and people. This can be also use in different ways like in work, school requirements, projects, assignments, research, thesis, etc. (Malathi et al., 2019). Different companies offered cloud storage like Google Drive and One Drive that been using by many people, governments, private companies, etc. (Yuhuan, 2017) Uploading and storing files via cloud storage can be a good strategy especially if you are using this with your important files (Khatod et al., 2020). Sharing cloud storage with different person can ease the problem in providing all the needed files to everyone (Machida et al., 2020). But this can bring some problem in concern to the privacy of each file being shared with others. So, the researcher proposed a file encryption/decryption using blowfish algorithm to secure the file before this can be uploaded on the cloud storage that was shared with others.

Cryptography is the process of hiding information and can achieve security by encoding messages so that this can't be read (Hazhirpasand & Ghafari, 2021). Using cryptography, it can prevent modification and unauthorized access of the file during the transmission and address data privacy preservation (Abdulla & Rana, 2021) (Radhika et al., 2021). Some popular symmetric-key block ciphers currently available this includes DES, 3DES, CAST5, RC6, CAST5, Twofish, Serpent, AES, and IDEA (Elgeldawi et al., 2019).

Blowfish algorithm was designed by Bruce Schneier in 1994; this aims to replace the outdated DES and it is a symmetric block cipher. Blowfish is a 64-bit variable length symmetric block cipher (Schneier, 1994). Blowfish is one of the fastest, compact, easy to understand, easy to implement, free alternative to existing encryption algorithms and features variable security level except when changing keys (Quilala et al., 2018). Blowfish algorithm consists of two parts-key expansion and data encryption. In the key expansion, applying XOR to the variable length key and plaintext are used to produce the subkeys and generate the four key-dependent s-boxes. Each round requires around four kB which made the algorithm inapplicable for devices with a small memory like a smart card and phone. Using the algorithm, computation of the subkeys every time results in slower operation which made the algorithm inefficient to use in an application that requires changing secret key frequently (Hashim et al., 2021).

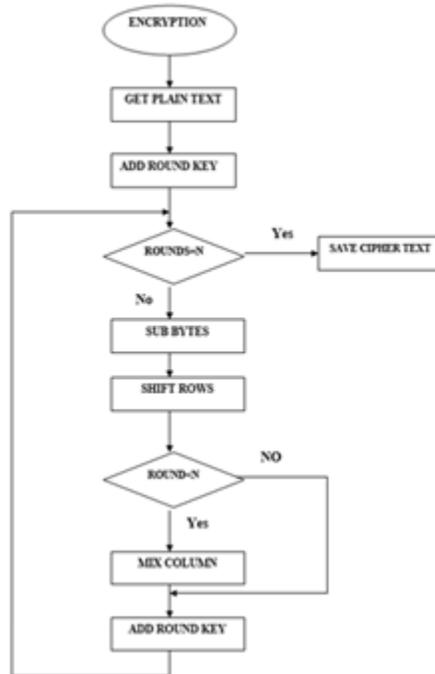
## Methodology

This will discuss the whole process of the proposed research.



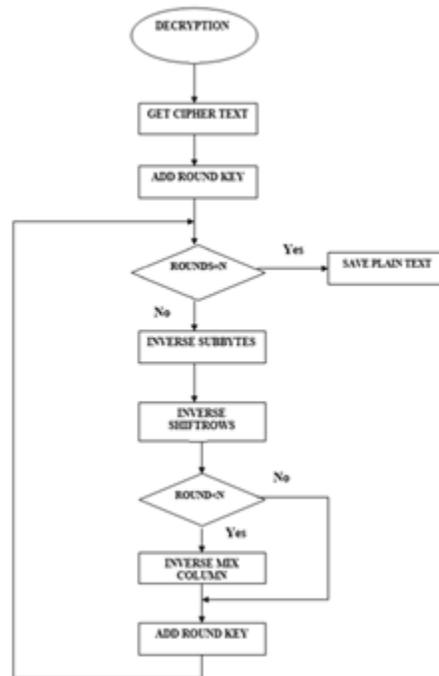
**Figure 1. System Architecture**

In figure 1, the file will be encrypted using blowfish algorithm with password security and the file will be uploaded on the cloud storage. In decrypting, choose the encrypted file in the cloud storage and enter the correct password and the file will now be decrypted and readable.



**Figure 2. Encryption Process Flowchart**

In figure 2, the user will get the plain text and then add a round key. If the Rounds=N is yes it will save a cipher text, and if the Rounds=N is no it process a sub bytes and shift rows. A Round<N is yes it will mix the column and if no both are going to add round key and proceed again to Rounds=N.



**Figure 3. Decryption Process Flowchart**

In figure 3, the user will get the cipher text and it will add round key. If Round is no, it will inverse the sub bytes and inverse shift rows, otherwise it will save plain text. If Round is yes, it will inverse mix column and if no it will proceed to add round key.

### Step by step process of Blowfish Algorithm

(Al-Kateeb & Mohammed, 2020)(Aldarwbi & Al-Kharobi, 2017)(de Los Reyes et al., 2019)(Gamido, 2020)(Hameed & Ali, 2019)(Kim & Kim, 2019)(Li & Liu, 2020)(Xu et al., 2020)

- 1 Initiate the substitution box (Sbox) and permutation box (Pbox). The Pbox entries are shown as the Pi in the diagram above. There are a total of 18 Pbox entries.
- 2 Next, we split our 64-bit plaintext into two equal blocks, L and R.
- 3 Next, we enter an encryption loop that runs 16 times. The following steps take place in each loop:
  - a. We XOR L with Pi, where i depends on the loop's current iteration.
  - b. We then XOR R with F, which is a function of L that makes use of the Sbox split into 4 blocks. The overview of the F function is shown in the image below.
  - c. Finally, L and R are swapped before the loop enters its next iteration.
- 4 After the loop finishes, L and R are swapped once more.
- 5 Next, we make use of our last two unused Pbox entries by XORing R with P17 and L with P18.
- 6 Finally, we combine L and R to retrieve the ciphertext.

## Results and Discussions

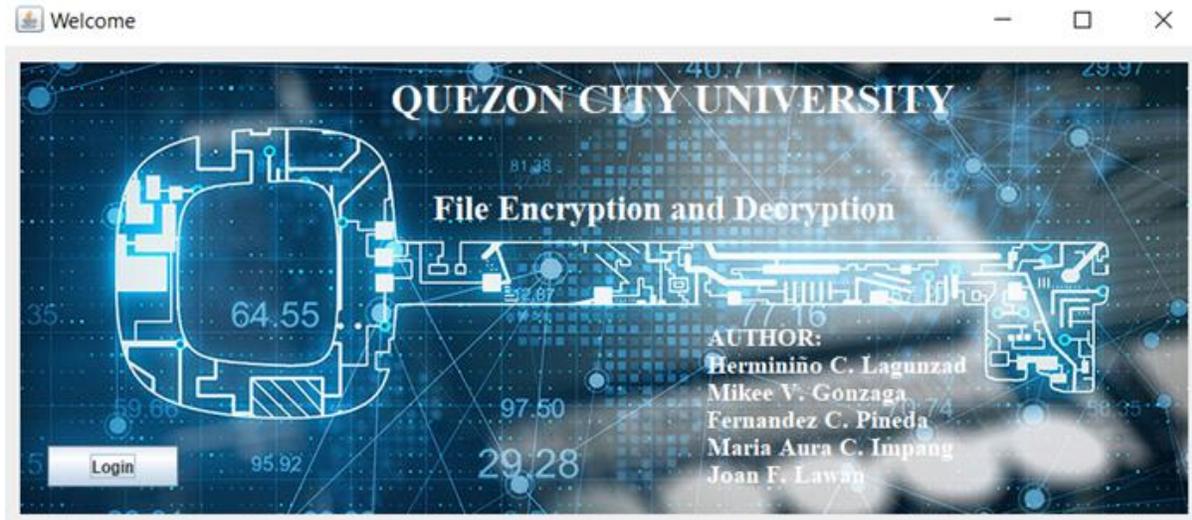


Figure 4. Welcome Page

This shows the main page of the application as shown in figure 4.

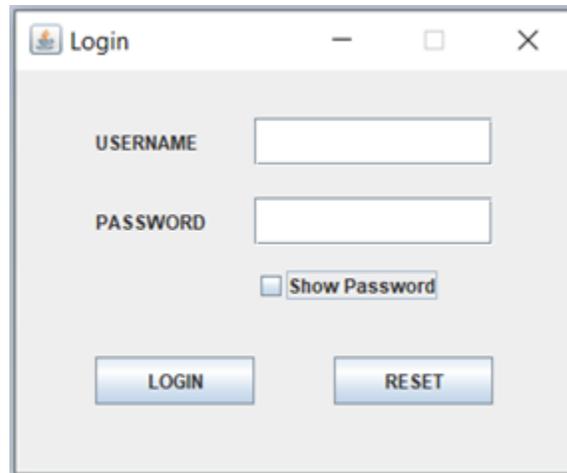
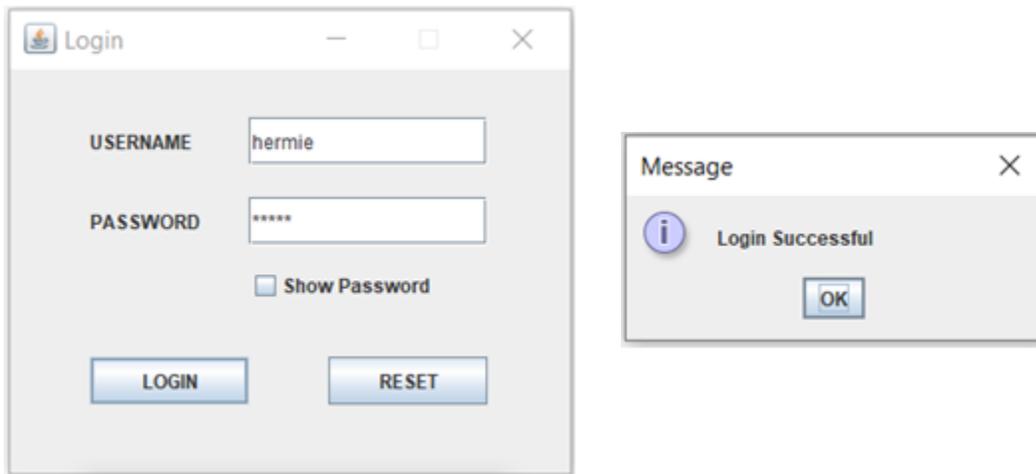


Figure 5. Login Page

In figure 5, the user may need to enter the correct username and password to use the application.



**Figure 6. Login Successful**

If the user entered the correct username and password, he/she can now use the application as shown in figure 6.



**Figure 7. File Encryption/Decryption**

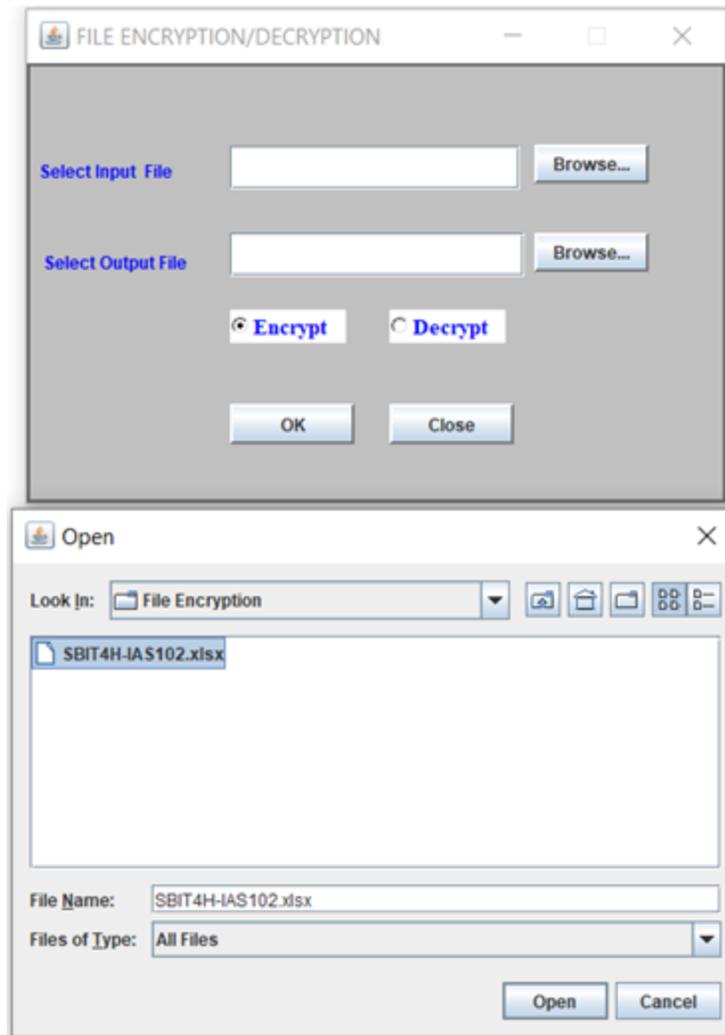
In figure 7, the user can now encrypt and decrypt file.

PC > Documents > File Encryption

Name	Date modified	Type	Size
 SBIT4H-IAS102.xlsx	28/11/2021 8:53 AM	Microsoft Excel Worksheet	1,965 KB

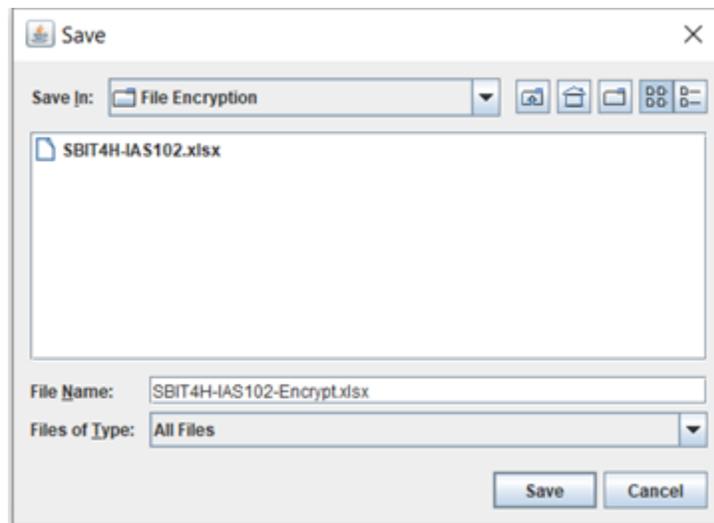
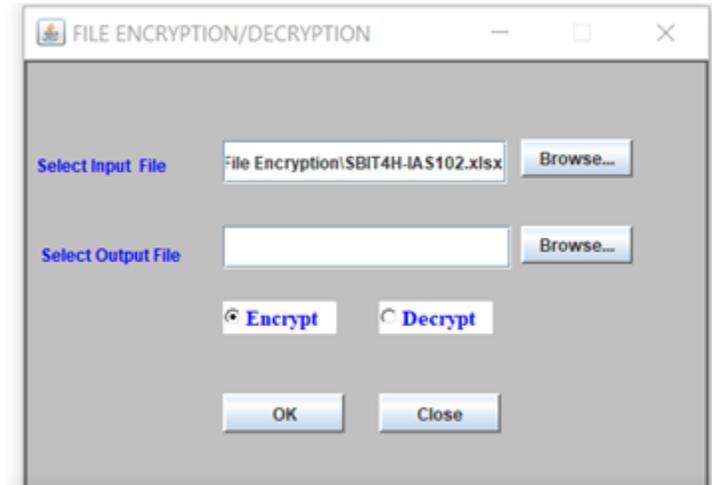
**Figure 8. Original File**

Figure 8 shows the original file that will be use for our encryption process.



**Figure 9. Select File for Encryption**

Figure 9 shows the file selection process where you can select the file you want to encrypt.



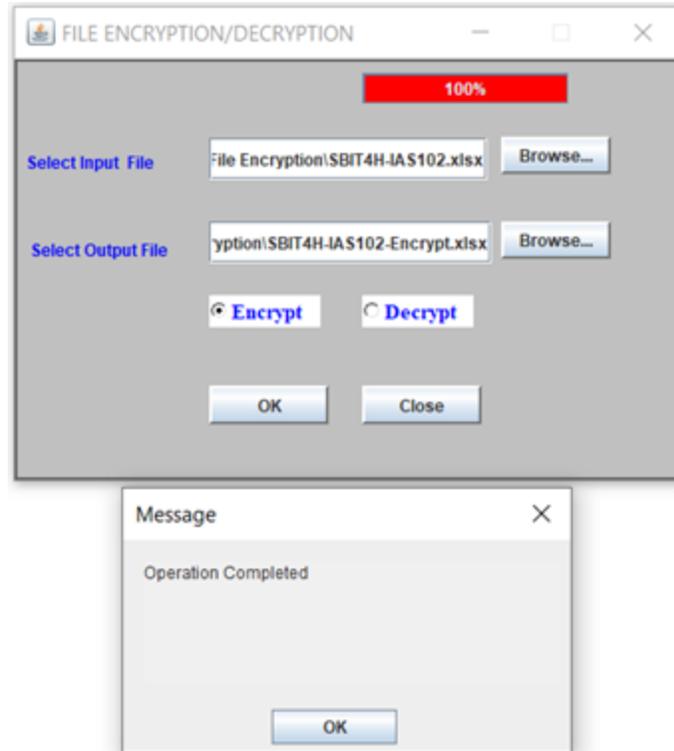
**Figure 10. Select File for Encryption Output**

In select input and output file, you need to select either the same file or different file for your input and output file. In selecting two different files for this process, will prevent the original file for corruption. After selecting the file, you need to check the Encrypt combo box then click OK as shown in figure 10.



**Figure 11. Encrypt Password**

Another form will appear requesting the password you may want to apply as show in figure 11.



**Figure 12. File Encryption Successful**

After entering the password, a message box will appear “Operation Completed”. This means that the file has been encrypted and ready for sharing as shown in figure 12.

PC > Documents > File Encryption

Name	Date modified	Type	Size
SBIT4H-IAS102.xlsx	28/11/2021 8:53 AM	Microsoft Excel Worksheet	1,965 KB
SBIT4H-IAS102-Encrypt.xlsx	28/11/2021 8:55 AM	Microsoft Excel Worksheet	1,965 KB

**Figure 13. Encrypted File Created**

After the encryption process successful, a new file will be created for the encrypted file as shown in figure 13.

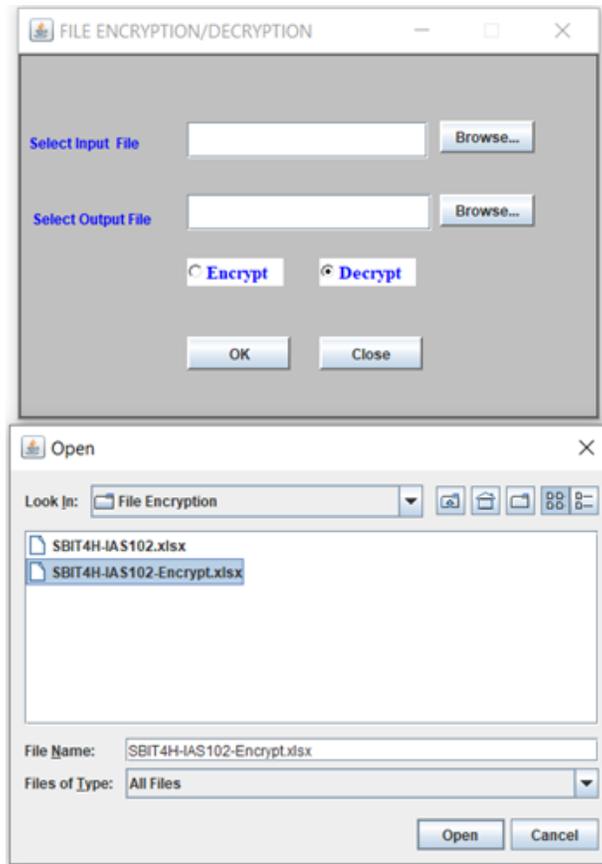


Figure 14. Select File for Decryption

In figure 14, the user may need to select the encrypted file for this process.

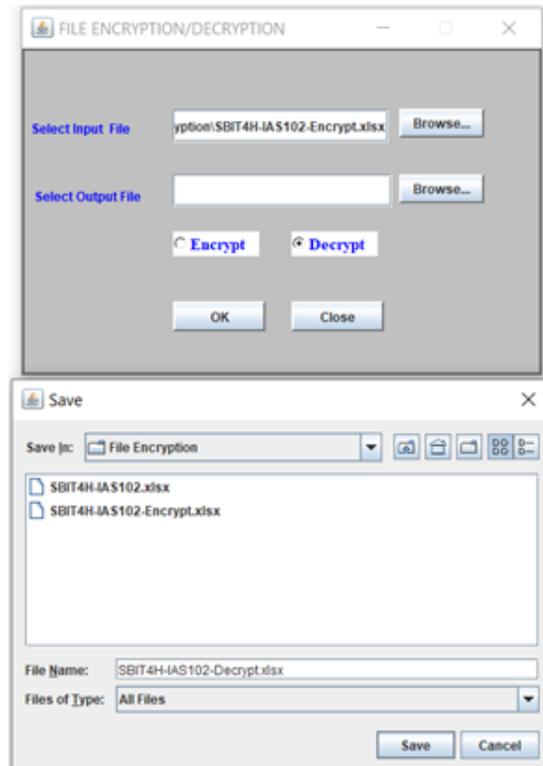


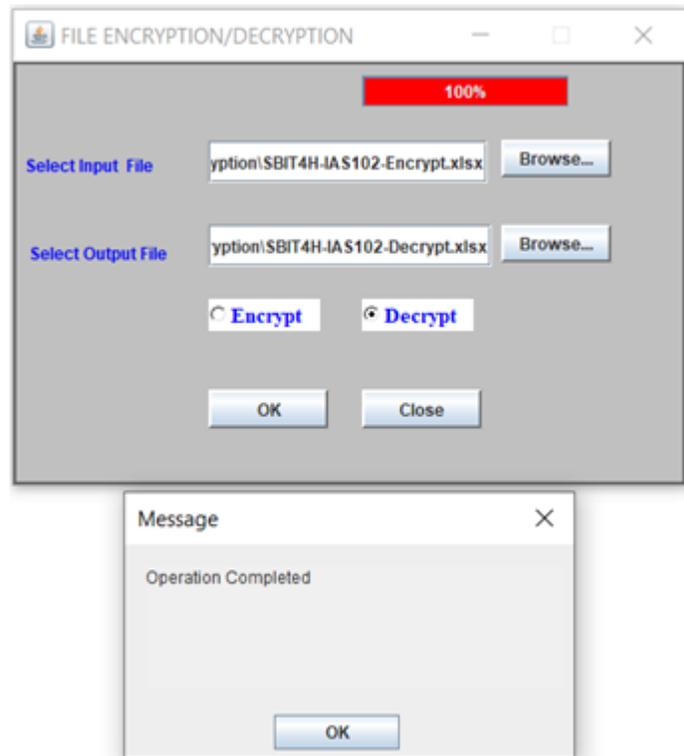
Figure 15. Select File for decryption Output

In figure 15, the user will select the file that needs to be decrypt and the user has the choice of selecting two different file or one file only for this process. Then the user needs to click the Decrypt combo box then click OK.



**Figure 16. Decrypt Password**

After clicking the OK button, the password form will appear, and you need to enter the same password that entered during encryption process as shown in figure16.



**Figure 17. Decryption Successful**

In figure 17, shows the decryption process is completed after entering the right password. The file is now available for viewing.

PC > Documents > File Encryption

Name	Date modified	Type	Size
 SBIT4H-IAS102.xlsx	28/11/2021 8:53 AM	Microsoft Excel Worksheet	1,965 KB
 SBIT4H-IAS102-Decrypt.xlsx	28/11/2021 8:56 AM	Microsoft Excel Worksheet	1,965 KB
 SBIT4H-IAS102-Encrypt.xlsx	28/11/2021 8:55 AM	Microsoft Excel Worksheet	1,965 KB

**Figure 18. Decrypted File Created**

In figure 18, after a successful decryption process, a file will be created and is now readable.

### Acknowledgement

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## Quality and Safety Assessment of a Developed Solar Thermal Processing System for Cashew (*Anacardium occidentale*) Kernels Processing

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*Abstract - In many instances, when designing and building an equipment for food applications, there exists a gap between efficiency and food safety. Machines are efficient but the safety of the food that it processes were not considered. These machines are deemed inappropriate once introduced to potential users. The study aims to assess the quality and safety of a developed concentrated solar thermal processing (CSTP) system for cashew kernels roasting for local processors in Cagayan de Oro, Philippines. Microbiological and physico-chemical analyses were conducted and evaluated using the Philippine National Standards (PNS) as reference for specifications. Moisture, color, and microbial content are well within the standards of maximum 5%, white to brown, and negative to *E. coli* and *Salmonella*, respectively. Breakage during processing from measuring size per kilogram was also very minimal at below 5%. These results show that a localized, cheaper, and readily fabricated CSTP system can produce roasted cashew kernels within PNS and can be adopted for use for a more efficient and quality and safety compliant processing.*

*Keywords - Assessment; cashew; solar; thermal processing; quality and safety*

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### Introduction

One of the challenges faced by rural farmers is the lack of access to processing equipment that could value add their produce especially when there is surplus of harvest. Low mechanization of crops in the Philippines has tremendous impacts on socioeconomic status, labour productivity and farm income, among others (PCARRD, 2009). There is available equipment in the market, but it is either too expensive or not fit for the farmer's produce. Local fabrication tailor fitting an equipment according to the groups of produce, i.e. grains, nuts, etc., is seen to be a solution to address the demands for farm modernization with consideration to servicing that will now be locally available. It has also been observed that quality and safety of processed products has been a major concern of consumers (FSN, 2020) as well as a basic human right (WHO, 2019). More and more humans are also interested in foods with bioactive compounds for the health benefits these foods provide. In the Philippines and globally, cashew kernels are considered a high value product due to its taste and bioactive compounds (Alasalvar, 2015).

As a major tourist food souvenir in the Philippines, cashew kernels among other nuts are always a product that is worthy of assistance especially in the process standardization. Roasting being on of the processes has still been done manually even up to today by majority of cashew kernel local processors. The efficiency of the manual roasting process is low. Availability of roasting machines is minimal or the price is beyond the capacity of local micro and small cashew enterprises in Cagayan de Oro City, Philippines. Electricity is also sometimes not available in farms and use of these electricity-based equipment is not practical. To address this, the fabrication laboratory of the USTP has developed a concentrated solar thermal processor that is capable of roasting nuts and other produce and electricity-independent.

Therefore, this study is aimed at assessing the quality and safety of cashew kernels roasted using a developed concentrated solar thermal processing system in terms of its physico-chemical and microbial properties.

## Methodology

Procurement of cashew kernels. Good quality cashew kernels were procured direct from the farm at Lumbia, Cagayan de Oro, Philippines based on the specifications in the Philippine National Standards for Cashew (PNS/BAFPS 59:2008). The cashew kernels are pre-dried and peeled ready for roasting.

Roasting of cashew kernels. The plain cashew nuts were roasted in the roasting chamber of the concentrated solar thermal processor. It is roasted at 180°C for 30 minutes with the drum roaster mechanically spins to ensure equal roasting.

Proximate analysis. Calories, moisture, protein, fat, ash and carbohydrates of the samples were determined using the methods recommended by the OMA AOAC (2007).

Physico-chemical analyses. Color and percent breakage were analysed. Color was analysed through high resolution photography of cashew kernels from raw to fully roasted at a 10-minute interval and quantified using a Konica-Minolta CR 400 Chroma Meter. Percent breakage is calculated by measuring the total broken kernels and dividing it with the total weight of the kernels and multiplying it by 100.

Microbial analyses. Plain and roasted cashew kernels were subjected to aerobic plate count, yeast and mold count, Salmonella detection and E. coli enumeration. The methods of analyses were based on the Bacteriological Analytical Manual.

## Results and Discussions

Proximate analyses. Table 1 shows the chemical composition of cashew kernels. More or less, the values can be compared to those provided by the Philippine Food Composition Table (PhilFCT, 2021) for roasted cashew kernels.

**Table 1. Chemical composition (g/100g) of plain and roasted cashew kernels**

Parameter (g/100g)	Plain cashew kernel	CSTP Roasted cashew kernel
<b>Calories, kcal</b>	<b>528.94</b>	<b>618.98</b>
<b>Fat</b>	<b>38.80</b>	<b>46.78</b>
<b>Protein</b>	<b>21.75</b>	<b>17.84</b>
<b>Moisture content</b>	<b>6.14</b>	<b>2.10</b>
<b>Ash</b>	<b>2.45</b>	<b>2.63</b>
<b>Carbohydrate</b>	<b>27.10</b>	<b>31.65</b>

Calories, in kcal, is seen to increase as a result of the loss of moisture and concentration of fat content with the kernels. These results coincide with studies such as that in potatoes (Ramasawmy, et al., 1999) and some tree nuts (Ghazzawi, 2017). Roasting has also resulted in the decrease of protein which can be explained by the denaturation of some amino acids at high temperatures. These are also observed in studies on roasting temperatures and protein in beef patties (Xia, et al., 2021), flaxseed meal (Waszkowiak, 2020) and cashews (Yan, et al., 2021).

**Table 2. Average color profile of cashew kernels**

Parameter	Plain cashew kernel	CSTP Roasted cashew kernel
<b>Color output</b>		
<b>Time</b>	0 minutes	35 minutes
<b>L*a*b* values</b>	72.47*2.57*20.25	61.55*8.45*27.14
<b>% Breakage</b>	-	3.79%

Roasting was stopped when the color changed from whitish brown to brown. Table 2 shows that at 35 minutes, the cashew kernels are already in a dark brown color which is no longer desirable. As such, it was determined that the roasting time, provided temperature of 180°C is reached will last for 30 minutes to produce safe and quality roasted cashews.

The L\*a\*b\* values are also called the tri-stimulus model created by Richard Hunter in the 1940's. The L\*a\*b\* stands for lightness, red/green value and blue/yellow value, respectively. The higher the L\* color means that it is leaning toward the lighter portion of the chart (Xrite, 2021).

A percent breakage of 3.79% indicates that the spinning motion of the roaster can produce roasted cashew kernels that are of high efficiency in terms of minimal loss from breakage without the need for human labor. There are no breakage percentage for the plain cashew kernels as it was already set to only use good quality cashew kernels for the roasting process.

**Table 3. Microbial analyses of plain and roasted cashew kernels**

Parameter (g/100g)	Plain cashew kernel	CSTP Roasted cashew kernel
Aerobic plate count	1.31 x 10 <sup>5</sup>	1.20 x 10 <sup>5</sup> CFU/g
Yeast and molds	77 CFU/g	17 CFU/g
<i>E. coli</i>	<3.0 MPN/g	<3.0 MPN/g
<i>Salmonella</i>	Not detected	Not detected

Microbial analyses result presented in Table 3 shows that roasting, although produces heat that can potentially destroy viable microorganisms, but it is not enough to kill a lot (Britton, et.al., 2021) due to the inherent amount present in the raw material. What is more important is to ensure that the moisture is within standard as low moisture has a positive effect towards the quality (Shirmohammadi, et.al., no date) and safety (Shakerardekani, et.al., 2019) of the product during storage.

*E. coli* and *Salmonella* are pathogenic microorganisms that may indicate faecal contamination in food. The absence of *Salmonella* and *E. coli* below the acceptable standard of 3 MPN/g (FDA, 2013) indicates that the roasted cashew kernels produced using the CSTP is safe for human consumption.

The reduction of yeast and molds from the plain cashew kernels to the roasted kernels are within expectation given that low resistance of many yeasts and molds species to dry heat (Scott and Bernard, 1985). A 106/g aerobic count and lower is indicative of acceptable microorganism's level for nuts (Irtwange and Oshode, 2009). The results may relate to the effectivity of pre-treatment of plain cashew kernels prior to roasting. Overall, the microbial results show that the use of CSTP as an economical roaster for nuts is viable.

### Conclusion and Recommendations

The study has shown that farm mechanization can be fulfilled by local fabrication of an efficient and safe food producing machine in this case, a concentrated solar thermal processing (CSTP) system for roasting. With minimal changes in the microbial load before and after roasting, this suggests the importance of following Good Manufacturing Practices during the preprocessing treatments to produce plain cashew kernels. In general, based on physico-chemical, proximate analysis and microbial profile data, the CSTP is a suitable equipment to roast cashew nuts.

#### Acknowledgement

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## **Performance and Capabilities of Automated a Solar-Powered Floating-Type Aeration System for Aquaculture Ponds**

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*Abstract - Aeration improves water quality in the pond and make it more favorable to fish environment. The Automated Solar Powered Floating Type Aeration System (ASPFTAS) was designed based on environmental requirement and actual characteristics of fresh water fishpond. The system consists of platform, power system, controllers with sensor, signalling and aerator. Machine possessed the capability to monitor the real time condition of the water, record and saved the data in an SD card and transmit data to mobile phones. The oxygen transfer rate (OTR) of ASPFTAS recorded 0.07 kg of oxygen infused in the water in one (1) hour using the four diffusers. The standard aeration efficiency attained during the test was 0.2710 kg of oxygen/hp-hr. The standard oxygen transfer efficiency was 0.36 at 18 kg of oxygen mass transferred by aerator into the fishpond water. The results of aeration test rated highly effective; the dissolved oxygen level increased 1.32 ppm in 10 minutes test. The performance of ASPFTAS using 1, 2, 3 and 4 diffusers at different depths, distances and different time of aeration revealed significantly difference among treatments. The evaluation of process controller, sensors and signalling system conducted in a laboratory for one hour revealed highly sensitive.*

*Keywords - Aeration system, Dissolved Oxygen, Oxygen Transfer Rate, Solar-powered aerator, Automation*

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### **Introduction**

Fisheries are one of the major industries in the agriculture sector. It is composed of three subsectors, namely: commercial fisheries, municipal fisheries, and aquaculture. Based on the recent national accounting estimates, fisheries sector contributes 19.6% of the total Gross Value Added (GVA) in agriculture and 1.8% of the total GDP. The Philippines is ranked 7th among the top fish producing countries in the world in 2012. However, since 2010 its economic contribution has been declining (PSA, 2014). Nowadays, aquaculture sectors are moving towards highly intensive farming to significantly increase the production and contest the growing demand as projected years to come, but the chances of risk increased due to management failures. In addition, the intensive production does not have enough facilities and equipment to maintain since the acquisition and installation costs are highly expensive in developing countries like the Philippines.

Modern aquaculture experience suggests that about 2,000 kg/ha of most species of shrimp and fish including tilapia can be produce in ponds without aeration. With proper aeration, it is reasonable to expect a production of up to 6,000 kg/ha. Tilapia are a species that can tolerate low dissolved oxygen (DO) with production in excess of 5,000 kg/ha in unaerated ponds (Oakes, et al., 2011). The use of an aeration system in pond increases the dissolved oxygen levels; it creates water movement, it enhances fish productivity, makes pond healthier and prevents unwanted vegetation growth. A diffused aeration system works by pushing the air from bottom to top of the pond water, releasing it into thousands of tiny bubbles that rise to the surface and disrupt the thermocline. This water movement provides a more uniform oxygen level and temperature throughout the entire body of water.

### **Research Objectives**

The general objective of the study was to design and automate a solar-powered floating type aeration system to improve dissolved oxygen in the fishpond. Specifically, the study aimed to: (a) evaluate

the aeration performance aeration system; (b) evaluate the automation capabilities of SPFTAS in improving the dissolved oxygen level; and, (c) evaluate the sensitivity response of automation system.

## Methodology

### Materials and Methods

#### Design of Automated SPFTAS

The ASPFTAS (Figure 1) was fabricated based on the design requirements of the aeration system, solar power system, buoyancy control system (floating platform), process control and sensor system, and signalling system.

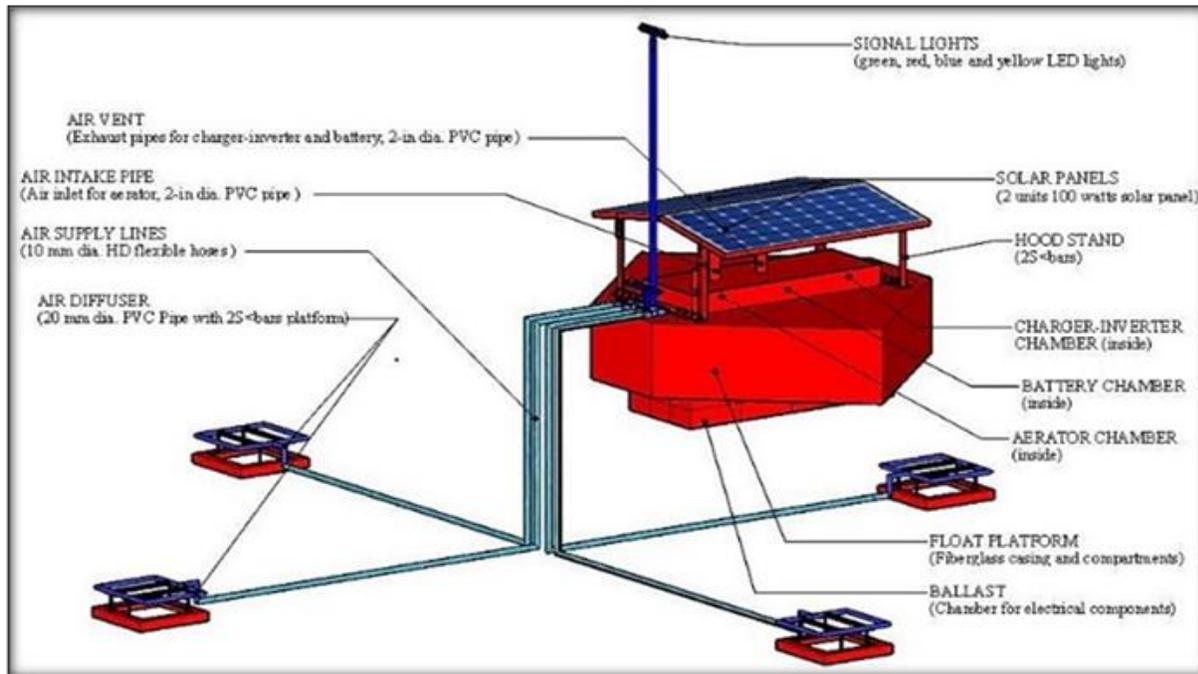


Figure 1. Design of ASPFTAS

#### Aeration System

The aeration system consists of 180 watts aerator to supply the volume of air to supply DO requirement. The aerator used a vortex type air pump with input rating of 220 volts alternating current and pressure output of 8.0 kPa. Operated with AC power and connected to relay switch coupled to a 220-volt outlet from power inverter.

The SPFTAS is equipped with four (4) diffusers made of 20.0 mm outside diameter perforated PVC pipes with a metal base platform made from a 20 mm x 20 mm x 5 mm angle bar. The diffusers are 10.0-mm diameter chemical hose feeder lines and are attached individually to a PVC valve (ball-type) valve.

#### Solar Power System

The system power requirement used 196 watts to operate the 180 watts aerator and its accessories in 1 hr. The total power requirement to operate 5 hrs per day was 980 watts. Since the ASPTAS can only deplete the battery charge level to 50%, the system required battery capacity was 1960 watts or a battery with bank size of 163 ampere-hour. The ASPFTAS used a 12 V- 200 Ah deep cycle lead-acid type storage battery. The system used 3,000 watts inverter-charger with an actual rating of 2,100 watts to transform direct current power into alternating current and has an output voltage of 220 volts and 6 ampere current

rating. Based on the power requirement the ASPFTAS needed to use 2 solar panels, each with 100 watts capacity to fully charge the battery in 6 hours. The installation and deployment of SPFTAS depended on the size and shape of the pond. The pond that was used in

### Installation of SPFTAS and Pond Layout

the test and evaluation had a dimension of 44 m x 44 m. The minimum water depth was 0.8 m. The pond layout and positioning of the SPFTAS in the performance evaluation are illustrated in Figures 2 and 3.

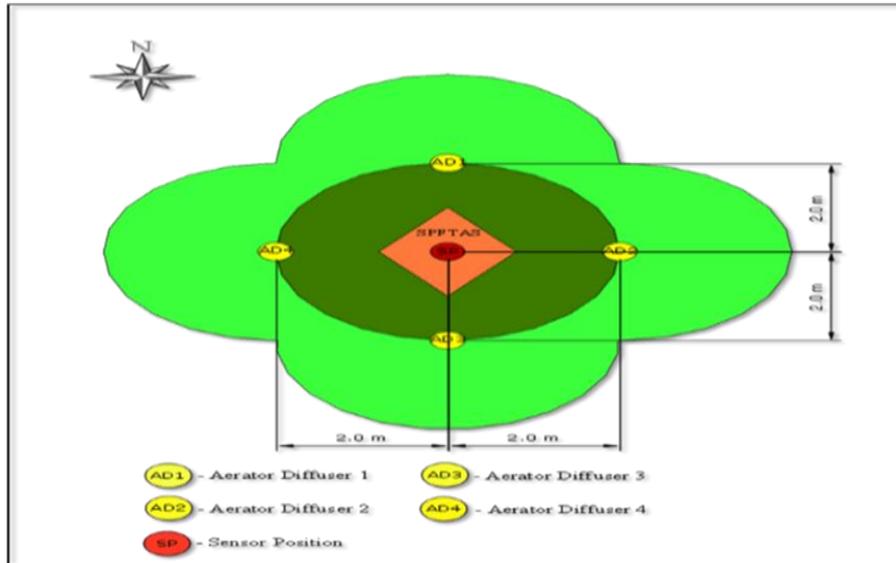


Figure 2. Diffuser layout and set-up of SPFTAS for the evaluation of aerator performance, sensitivity of sensor and signaling system.

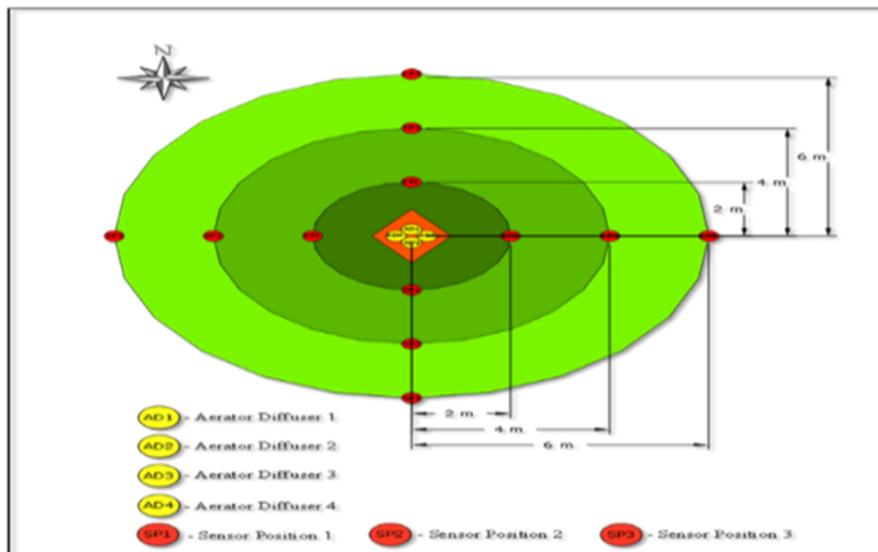


Figure 3. Set-up of SPFTAS and sensor layout for 4 diffusers for measurement of DO concentration at various distances and depth.

## Performance and Capabilities Testing and Evaluation

### Aeration Performance

The performance evaluation of aerator was measured as either standard oxygen transfer rate (SOTR) or standard aeration efficiency (SAE) and standard oxygen transfer efficiency (SOTE). The SOTR is the amount of oxygen added to the water in one hour under standard conditions expressed as kilograms of O<sub>2</sub>/hr (APHA, 1985). The SAE is the standard oxygen transfer rate divided by the horsepower (hp) of the unit, expressed as kg of O<sub>2</sub>/hp-hr transferred to the water (Lawson and Merry, 1993). The SOTE refers to the fraction of oxygen in an input airflow dissolved under the standard condition. It is expressed as SOTR per (kg/s).

The aerator dissolved oxygen transfer capacity. The rate of oxygen transferred by the aerator is the aerator capacity (AC), which is defined as the rate of oxygen transferred in one hour operation divided by dissolved oxygen requirement per liter. It is expressed in cubic-meter per hour. The following formulas were used in the determination of performance parameters:

$$\text{SOTR} = (K_L a_{20}) \times C_{S,20} \times V \quad (1)$$

where: SOTR - standard oxygen transfer rate, kg of O<sub>2</sub>/hr

$K_L a_{20}$  - volumetric mass transfer coefficient at standard condition for measuring probe, temperature 20 and 1 atm, second<sup>-1</sup>

$C_{S,20}$  - dissolved oxygen saturation concentration at standard condition measuring probe, temperature 20 and 1 atm, mg/L

V- volume of water, m<sup>3</sup>

$$\text{SAE} = \frac{\text{SOTR}}{\text{Power Input}} \quad (2)$$

where: SAE - standard aeration efficiency, kg of O<sub>2</sub>/kWh

SOTR - standard oxygen transfer rate, kg of O<sub>2</sub>/hr

Power Input - aeration power, watts

$$\text{SOTE} = \frac{\text{SOTR}}{W_{O_2}} \quad (3)$$

where: SOTE - standard oxygen transfer efficiency

SOTR - standard oxygen transfer rate, kg of O<sub>2</sub>/hr

$W_{O_2}$  - mass flow of oxygen in air stream

$$\text{AC} = \frac{\text{SOTR}}{\text{OR}} \quad (4)$$

where: SOTE - standard oxygen transfer efficiency

OR - oxygen requirement (mg/l)

### Test and Evaluation of Dissolved Oxygen Levels

The dissolved oxygen levels of concentration in water using four diffusers at different distances from the device in a given time intervals and water depth were determined as the dispersion of oxygen in the test pond. The performance evaluation of SPFTAS in maintaining dissolved oxygen level was conducted in the fishpond with stocking rate of a 15 fingerlings/m<sup>3</sup>. The level of DO after the operation was measured to determine the increase of DO level in the water and effectivity of SPFTAS in increasing the level of DO at different time duration. Table 1 shows the performance parameters for the evaluation SPFTAS effectivity and the following threshold values that were used as guide in rating the SPFTAS:

**Table 1. Performance parameters for the evaluation SPFTAS effectivity**

PARAMETERS	HE	ME	LE	FAIL
DO increase 1 ppm in $\leq 10$ min operation	✓			
DO increase 1 ppm in $\leq 15$ min operation		✓		
DO increase 1 ppm in $\leq 20$ min operation			✓	
DO increase 1 ppm in $>20$ min operation				✓

Highly effective (HE): when the dissolved oxygen level increase 1 ppm from initial DO level in 10 minutes operation within 2.0 m radius of influence

Moderately effective (ME): when the dissolved oxygen level increase 1 ppm from initial DO level in 15 minutes operation within 2.0 m radius of influence

Less effective (LE): when the dissolved oxygen level increase 1 ppm from initial DO level in 20 minutes operation within 2.0 m radius of influence

### Sensitivity of SPFTAS Process Controller

The sensitivity of process controller and signaling system was evaluated based on the timeliness it triggered the aerator to start when the dissolved oxygen level decreased below 3.0 ppm and the time it stopped when the dissolved oxygen level increased above 5.0 ppm. The signal lights were also observed if it had any of the condition set and if the horn sounded the alarm based on the programmed commands. The range of time durations for sensitivity ratings were as follow:

**Table 2. Performance parameters for the evaluation ASPFTAS controller sensitivity**

PARAMETERS	HS	MS	LS	FAIL
Response in $\leq 5$ sec	✓			
Response in $> 5 \leq 10$ sec		✓		
Response in $> 10 \leq 30$ sec			✓	
Response in $> 30$ sec				✓

Highly Sensitive (HS): when the system responds within 5 seconds

Moderately Sensitive (MS): when the system responds within 5-10 seconds

Less Sensitive (LS): when the system responds within 10-30 seconds

### Data Analysis

The regression analysis was used to describe the effects of different number of diffusers in relation to the dissolved oxygen level in a given time interval, and at different depth ranges. The characteristics of DO using four diffusers were analyzed using univariate analysis. The data were analyzed using SPSS version 22.

## Results and Discussions

### Aeration Performance and Efficiency

The test results obtained 0.07 kg of oxygen per hour Oxygen Transfer Rate using four (4) diffusers (Petrille, J. and Boyd, C.E., 1984). The Standard Aeration Efficiency obtained was 0.2710 kg of oxygen per hp-hr. The Standard Oxygen Transfer Efficiency attained during the test was 0.36 or equivalent to 18 kg of oxygen mass transferred by aerator into the water. The aeration capacity of ASPFTAS was computed by determining the volume of aerated water in an hour (m<sup>3</sup>/hr) based on the SOTR obtained. The aeration capacity of machine was 14.0 m<sup>3</sup>/hr. This is the volume of water that would be supplied by DO (0 ppm to

5 ppm). However, if the initial DO levelled 3 ppm at the start of the aeration process and the target is to increase it to 5 ppm the volume of water that could be aerated will be increased to 35.0 m<sup>3</sup>/hr.

### Dissolved Oxygen (DO) Levels

The evaluation of aeration performance was tested in the pond with a stocking rate of 15 pieces/m<sup>3</sup>. The stock size ranged from 2-3 cm and it was categorized as fingerlings. The water depth at the time of evaluation was 1.2 m in depth. The evaluation was conducted in 10-, 15- and 20-min aeration test. The results revealed that the dissolved oxygen level increased by 1.32 ppm. Since it exceeds 1.0 ppm after 10 min aeration threshold. The test was rated highly effective. It was also observed that the dissolved oxygen levels increased further after 15 and 20 min of aeration. Figure 4 indicates the levels of dissolved oxygen increased as the time of aeration is prolonged. This indicate that the designed aeration system is capable and has the ability to increase the dissolved oxygen level in the pond with 15 fingerlings/ m<sup>3</sup> stocking rate.

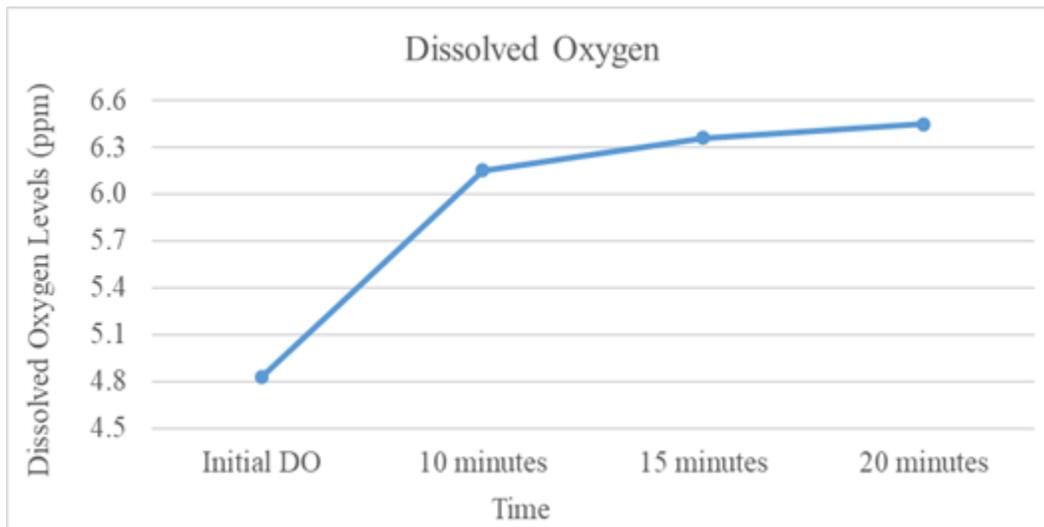


Figure 4. DO levels (ppm) on test evaluation of aeration effectiveness

### Performance of ASPFTAS in Dispersing Dissolved Oxygen

The performance of SPFTAS in dispersing dissolved oxygen was evaluated in three parameters: A varying depths from the surface (20 cm), middle (40 cm) and bottom (60 cm); distances at 2 m, 4 m and 6 m from the center, different time intervals of 1 hour, 2 hours and 3 hours.

### Dissolved Oxygen at Different Depths and Number of Diffusers

The results on DO without diffusers shows that at the upper water level was higher than the middle and bottom. The results also revealed that the dissolved oxygen was significantly different from every depth. The results on 1, 2 and 3 diffusers show that the DO were highest at the surface than the middle and bottom. The results using 1, 2 and 3 diffusers revealed that the dissolved oxygen levels were highly significant from each depth at different number of diffusers. The results of test using 4 diffusers shows that the DO at the surface was still the highest compared to that on the middle and on the bottom. The results of analysis revealed that the dissolved oxygen levels at different depths were significantly different among each other. Figure 5 shows the dissolved oxygen levels at different depths (20, 40, and 60 cm) using 1, 2, 3 and 4 diffusers.

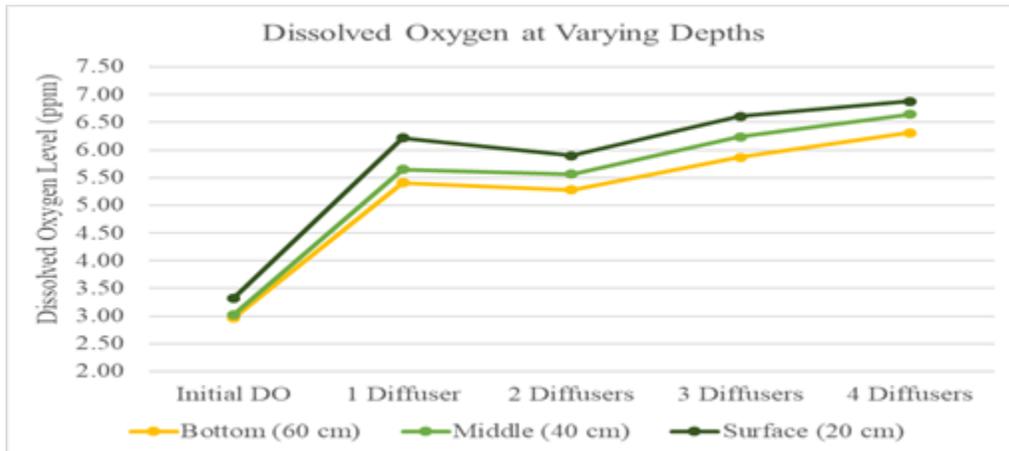


Figure 5. Dissolved Oxygen levels (ppm) at varying depths using 1, 2, 3 and 4 diffusers

### Dissolved Oxygen at Distances and Number of Diffusers

The results DO without diffuser showed that at 4 meters from the center was highest among all means. The results also revealed that the dissolved oxygen levels at different distances from the center were significantly different. The results on performance using 1, 2 and 3 diffusers revealed that the DO at the center was still the highest among other distances. The results also showed that the dissolved oxygen levels using the 1, 2 and 3 diffusers at different distances were significantly different from each other. The results on 4 diffusers showed that the DO at the center was higher than the DO at other distances. The results revealed that the dissolved oxygen levels at varying depths were not significantly different from each other using four diffusers. Figure 6 shows the dissolved oxygen levels at different distances (center, 2, 4, and 6 m) using 1, 2, 3 and 4 diffusers.

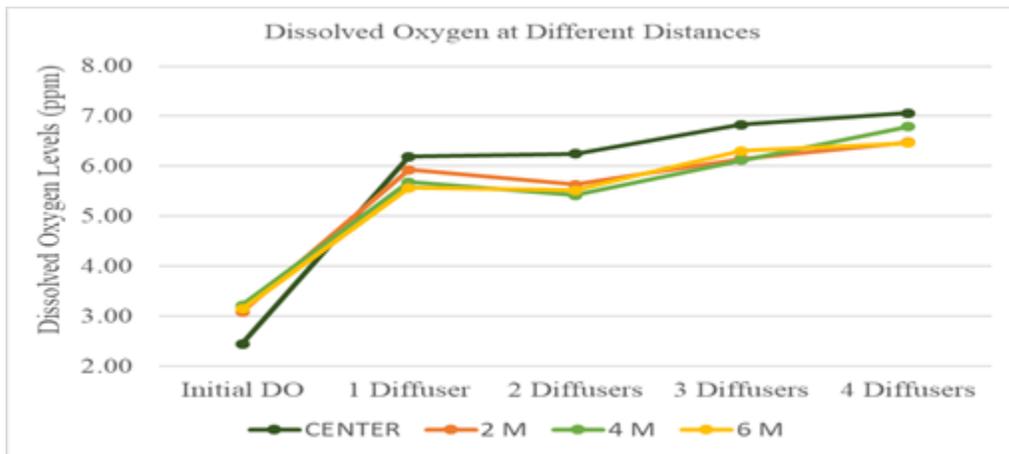


Figure 6. DO levels (ppm) at different distances using 1, 2, 3 and 4 diffusers

### Dissolved Oxygen at Time Intervals and Number of Diffusers

The results of performance showed that the DO after three hours of operation was highest among the DO levels at other time durations. The results revealed that the dissolved oxygen levels at different time intervals were significantly different. The results using 2, 3 and 4 diffusers revealed that the DO level after three hours of operation were constantly the highest among the DO levels at other time duration. The results also revealed that the dissolved oxygen levels at different time intervals were highly significant from

each other using 2, 3 and 4 diffusers. Figure 7 shows the dissolved oxygen levels at different time intervals (1, 2, and 3 hrs.) using 2, 3 and 4 diffusers.

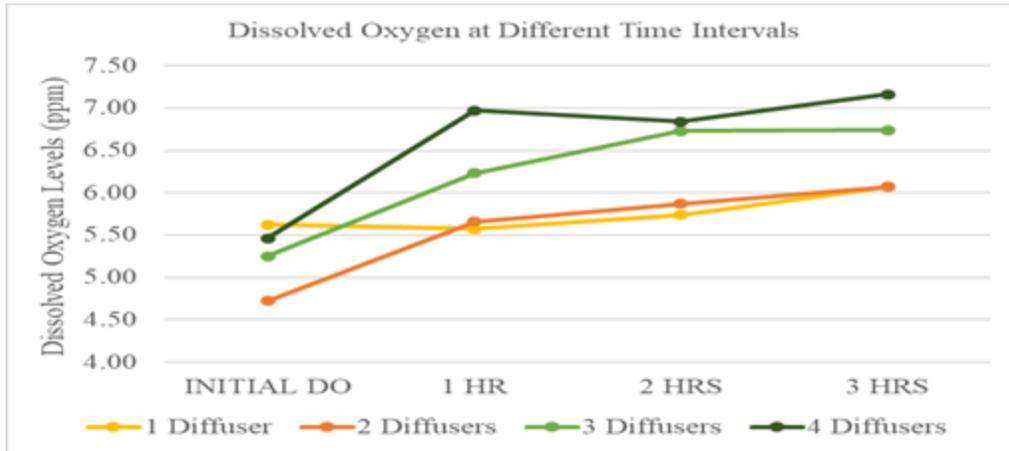


Figure 7. DO levels (ppm) at different time intervals using 1, 2, 3 and 4 diffusers

### Dissolved Oxygen Levels Performance

Analysis of the DO levels showed that it was affected by the number of diffusers used, time duration and temperature. The results also revealed that the DO levels using different numbers of diffuser were significant to each other, while the DO levels at different time durations and temperature were highly significant. DO levels at different depths and distances at four orientations (N, E, W, S) were not significant. The results revealed that the DO levels dispersed by using four diffusers had no difference with depths, distances and four orientations. The evaluation of performance involving all the parameters analyzed using multiple regression model had established the equation to predict DO level in the pond using SPFTAS. To predict the dissolved oxygen levels in the pond using SPFTAS, the regression equation is as follows:

$$\hat{DO}_p = \Gamma + \rho (\mathcal{D}) + \alpha (\Omega) + \delta (\Phi) + \tau (T) + \gamma (\Psi) =$$

Where:  $\hat{DO}_p$  = DO predicted

$\Gamma$  = intercept

$\rho$  = coefficient for number of diffusers

$\mathcal{D}$  = number of diffusers

$\alpha$  = coefficient for depth

$\Omega$  = depth

$\delta$  = coefficient for distance

$\Phi$  = distance

$\tau$  = coefficient for time

$T$  = time

$\gamma$  = coefficient for temperature

$\Psi$  = temperatures

## SPFTAS Automation System

### Process Controller, Sensor and Signalling System

The results of sensitivity analysis showed that most of the components involved in the automation process, data logging, and transmission of data, signalling and turning-on of aerator were highly sensitive. Most of the components responded within five seconds after initiation of command and functions. The aerator and the yellow light exhibited less sensitive when the DO level was at 5 ppm. The aerator responded 25 seconds after the horn was triggered and the DO level was at 5.0 ppm. This can be attributed to the weak mobile network signal in the area which caused the delay in the sending of data and this made the aerators respond late. Likewise, the signal lights responded late until the last command was initiated. The data transmission was also found to be moderately sensitive. This may be due to the location of the testing area resulting to a weak signal transmission. It was observed that only 15 out of the expected 22 messages sent were received through text messages (SMS); resulting in a 68% reliability. Table 58 shows the evaluation of data for the responses of the different component functions.

**Table 3. Sensitivity of automation components and signaling system responses to the mode of functions**

DO LEVEL MODE	DO (LEVEL)	RESPONSE TIME DELAT OF 1 CYCLE OPERATION							Data Logging	REMARKS
		LED				HORN	Sending Text	AERATOR		
		Yellow	Green	Blue	Red					
DO High	> 5.00	HS	HS					MS	HS	
DO Set Maximum Range	5.00	LS						MS	HS	
DO at Range (decreasing)	5.00 - 3.00	HS		HS				MS	HS	
DO Set Minimum Range	3	HS			HS	HS		MS	HS	HS
DO Lower	>3	HS				HS		MS	HS	
DO at Range (increasing)	3.00 - 5.00	HS		HS				MS	HS	
DO Set Maximum Range	5.00	LS				HS		MS	LS	HS
DO Increasing	> 5.00	HS	HS					MS	HS	
DO Set Maximum Range	5.00	HS						MS	HS	
DO at Range (decreasing)	5.00 - 3.00	HS		HS				MS	HS	
DO Set Minimum Range	3	HS			HS	HS		MS	HS	HS
DO Lower	>3	HS				HS		MS	HS	
DO at Range (increasing)	3.00 - 5.00	HS		HS				MS	HS	
DO Set Maximum Range	5.00	LS				HS		MS	LS	HS
DO Increasing	> 5.00	HS						MS	HS	

### Conclusion and Recommendations

The general objective of the study was to design and automate a solar powered floating type aeration system to improve dissolved oxygen in the fish pond. Specifically, it evaluated the dissolved oxygen level. In this study, the performance of SPFTAS was evaluated in many aspects. The sensitivity of sensors that initiated the automation mechanism was also evaluated and the responses of components installed. The economic analysis of SPFTAS was also taken. The automated SPFTAS was designed, installed and tested with all its components to improve water quality of fish pond. The SPFTAS was made of fiberglass, with two units of 100-watt solar panel and charge controller, one unit 12 volt-200 ampere-hour deep cycle battery, 12 volts – 220 volts power inverter and 180-watt vortex type aerator. The design could stand in fishpond environment. The sensors, signaling and alarm system triggered the full automation of SPFTAS.

- 1 The results of the test concluded that the SPFTAS has acceptable Oxygen Transfer Rate (OTR) and Aeration Efficiency (AE). The performance of aeration system in maintaining dissolved oxygen

level in intensive production system (15 pieces per cubic meter) in 20 minutes operation was highly effective in 2 m range and 1 m water depth.

- 2 The levels of dissolved oxygen dispersed at different depths and distances, and orientations exceeded the 5-ppm maintaining DO level requirement in fish pond using four diffusers. The means of DO levels of different numbers of diffusers used were enough to sustain the requirement and the highest mean reached 6.953 ppm. Therefore, the performance of SPFTAS was enough to improve the water quality in fish pond.
- 3 The overall performance of SPFTAS was significant at 1, 2, 3, and 4 diffusers, depths, distances and time. While in different orientations there were no significant differences. These results of analysis attested the positive impact of aeration system in terms of uniformed distribution of dissolved oxygen. Based on the results it concluded that the greater the number of diffusers installed, the higher is the DO level at any depth, time and distance. The prediction of device performances was estimated using the equation:  $\Delta\Theta_p = \Gamma + \rho (\Theta) + \alpha (\Omega) + \delta (\Phi) + \tau (T) + \gamma (\Psi)$ , with a standard error of 1.44
- 4 The results of the study on automation indicated that automated SPFTAS was verified as important device in real time monitoring, improving and maintaining water quality as well as in immediate response to the
- 5 water environment. Findings of the study also attested that the automation, signaling, alarm system, real time data logging and data transmission are developments in research, monitoring and adverse climatic condition. In general, the aeration process controller, sensors, alarm and signaling system are highly sensitive. Therefore, automation of SPFTAS is very much important to address the pressing problems in fish ponds.

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## The Potential Use of the Microcontroller-based Automated Disinfection Device (MADD) in Eliminating Bacteria in Fomites

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*Abstract - Ultraviolet (UV) radiation has been utilized as a germicidal or disinfectant for many years, particularly in the medical industry. With its potential to eliminate bacteria among fomites or any inanimate object that, when contaminated with or exposed to infectious agents, can transfer disease to a new host like parcels, the study on developing and designing a Microcontroller-based Automated Disinfection Device (MADD) using Arduino that can help eliminate bacteria found on parcels received by online shoppers was conducted during the first semester of the Academic Year 2020-2021 at Quezon City University (QCU). An evolutionary prototyping technique was adopted in developing and testing the MADD. The results show that MADD is durable, efficient, functional, and useful when it comes to disinfecting bacteria found on the surfaces of selected objects. The study concludes that aside from its present use, the microcontroller is useful when developing a technology like MADD, and it can be maximized when it is combined with other devices like the UV C light lamp to disinfect surfaces and objects that are possible carriers of disease-causing agents. Since MADD uses C++ programming language, it is suggested that using other programming languages may improve the device's efficiency. And lastly, improvement on MADD's over-all design and disinfecting ability is highly recommended.*

*Keywords - Microcontroller-based device, Disinfection device, Ultraviolet radiation disinfection, Fomites, Bacterial disinfection*

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### Introduction

For many years, ultraviolet (UV) radiation has been used as a germicidal or disinfectant, most notably in the medical industry (Reed, 2010). UV lights have been shown in studies to have germicidal properties, which means they kill bacteria and microbes (Levetin, et al. 2001). UV light technology has been used for disinfection purposes for centuries (Menziez, et al. 2003).

Ultraviolet Lights come in a variety of types and are used for a variety of purposes: Ultraviolet A, Ultraviolet B, and Ultraviolet C are the most commonly used in the industry (Hockberger, 2002). Ultraviolet A is a type of ultraviolet light that is less harmful than Ultraviolet B, but approximately 1,000 times less effective than Ultraviolet B and Ultraviolet C, which can cause skin aging and increase the risk of developing unusual skin cancer (Hockberger, 2000). While ultraviolet B is effective at inactivating SARS viruses, it is significantly less effective than ultraviolet C and significantly more dangerous to humans (Reed, 2010; Hockberger, 2002; Hockberger, 2000). UVB radiation is capable of penetrating the skin and eye. This type of Ultraviolet B has the potential to damage deoxyribonucleic acid (DNA), making it one of the risk factors for skin cancer and cataracts. While ultraviolet C is commonly used to disinfect air, water, and nonporous surfaces, it has been used to prevent the spread of bacteria (tuberculosis) for decades and is referred to as germicidal (Beggs, 2006).

SARS-CoV-2, the virus that causes Covid19, is an enveloped virus, which means that its genetic material is enclosed within a protein and lipid outer layer. The envelope contains spike proteins that allow the virus to attach to human cells during infection. SARS-CoV-2, like other enveloped respiratory viruses, has a labile envelope that degrades rapidly when exposed to surfactants found in cleaning agents and under certain environmental conditions. The risk of fomite-mediated transmission is proportional to the community's infection prevalence rate. the amount of virus that infected people expel, the deposition of expelled virus particles onto surfaces (fomites), which is affected by air flow and ventilation, the interaction of virus particles with environmental factors that cause damage to virus particles while airborne and on

fomites, the time interval between when a surface becomes contaminated and when a person touches it, the efficiency of virus particle transfer from fomite surfaces to hands and from hands to mucous membranes.

Due to the numerous variables that influence the efficiency of environmental transmission, the relative risk of fomite transmission of SARS-CoV-2 is considered low in comparison to direct contact, droplet transmission, or airborne transmission (Kampf, et al. 2020; Meyerowitz, et al. 2020). However, the proportion of SARS-CoV-2 infections acquired via surface (fomite) transmission is unknown (Kampf, et al. 2020; Meyerowitz, et al. 2020). There have been a few reports of Covid19 cases that may have been transmitted via fomite. Often, infections can be traced back to multiple transmission pathways. Transmission of fomite is difficult to establish conclusively, in part because respiratory transmission via asymptomatic individuals cannot be ruled out (Bae, et al. 2020; Cai, et al. 2020; Xie, et al. 2020). According to case reports, SARS-CoV-2 is spread between people by touching surfaces where an ill person has recently coughed or sneezed and then touching the mouth, nose, or eyes directly (Bae, et al. 2020; Cai, et al. 2020; Xie, et al. 2020). Hand hygiene acts as a barrier to the transmission of fomite and has been linked to a decreased risk of infection (Doung-Ngern, et al. 2020).

Quantitative microbial risk assessment (QMRA) studies have been conducted to characterize and understand the relative risk of SARS-CoV-2 fomite transmission, as well as to determine the need for and effectiveness of risk reduction measures. These studies' findings indicate that the risk of infection with SARS-CoV-2 via the fomite transmission route is low, generally less than 1 in 10,000, which means that each contact with a contaminated surface has a less than 1 in 10,000 chance of causing an infection (Wilson, et al. 2020; Harvey, et al. 2020; Pitol & Julian, 2020). Certain studies estimated exposure risks primarily by analyzing SARS-CoV-2 RNA quantification data from outdoor environments. They noted that their QMRA estimates are subject to uncertainty, which can be reduced by increasing the accuracy and precision of the data used in the models. Outdoor surfaces should have lower infectious SARS-CoV-2 concentrations than indoor surfaces due to air dilution and movement, as well as harsher environmental conditions such as sunlight. Additionally, one QMRA study evaluated the effectiveness of prevention measures for reducing the risk of fomite transmission and discovered that proper hand hygiene can significantly reduce the risk of SARS-CoV-2 transmission from contaminated surfaces, whereas daily surface disinfection had little effect on reducing estimated risks (Pitol & Julian, 2020).

Globally, the Covid19 pandemic has caused crisis and suffering, affecting commerce and trading, as people are fearful of venturing outside their homes to purchase necessities in order to avoid virus infection. With the rise of online shopping and delivery, disinfection becomes a necessity. Currently, a manual disinfection process is used globally, which involves spraying alcohol on the surface and wiping it clean with a clean towel. Online shopping and delivery have become popular and disinfecting the area where packages or parcels are received has become a common practice. The Department of Health (2020) issued Memorandum No. 2020-0157, which contains guidelines for cleaning and disinfecting in a variety of settings as a means of infection prevention and control against Covid19.

According to the guideline, disinfectants such as 70% ethyl alcohol and a strong bleach solution can be used to combat bacteria and viruses that cause Covid19, and it is recommended to mop or wipe surfaces directly or spray disinfectants directly on them. This technique has been implemented and is in use.

With the potential for UV light to kill bacteria on fomites or any inanimate object that, when contaminated or exposed to infectious agents, can transmit disease to a new host, such as parcels, the development of devices for disinfecting surfaces and other objects that can transmit bacterial or viral-causing diseases has become a trend. Microcontrollers are used in a wide variety of applications and systems (Hsiung, 1992). Multiple microcontrollers are frequently used in devices to perform specific tasks, such as an automated disinfection device (Hsiung, 1992).

Hence, research into the development and design of an automated disinfection device is necessary. Thus, the primary goal of this study is to develop a Microcontroller-based Automated Disinfection Device (MADD) based on the Arduino platform that is durable, efficient, functional, and useful for disinfecting and eliminating bacteria found on the surfaces of parcels received by online shoppers.

## Methodology

For many years, ultraviolet (UV) radiation has been used as a germicidal or disinfectant, most notably in the medical industry. With the potential to eradicate bacteria from fomites or any inanimate object that, when contaminated or exposed to infectious agents, can transmit disease to a new host, such as parcels, the study on developing and designing a Microcontroller-based Automated Disinfection Device (MADD) using Arduino that can assist in the elimination of bacteria found on parcels received by online shoppers was conducted during the first semester of the Academic Year 2020-2021 at Quezon City University (QCU).

To address the objectives of the study, the evolutionary prototyping technique was adopted in developing and testing the Microcontroller-based Automated Disinfection Device or MADD. Figure 1 shows the prototyping model used in the study.

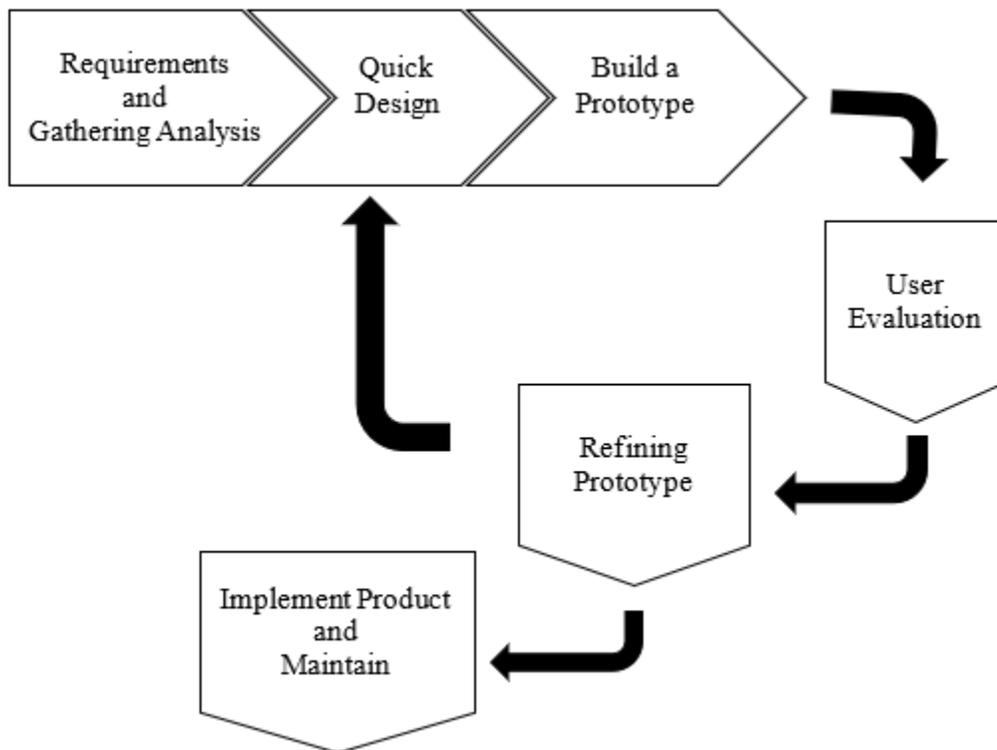
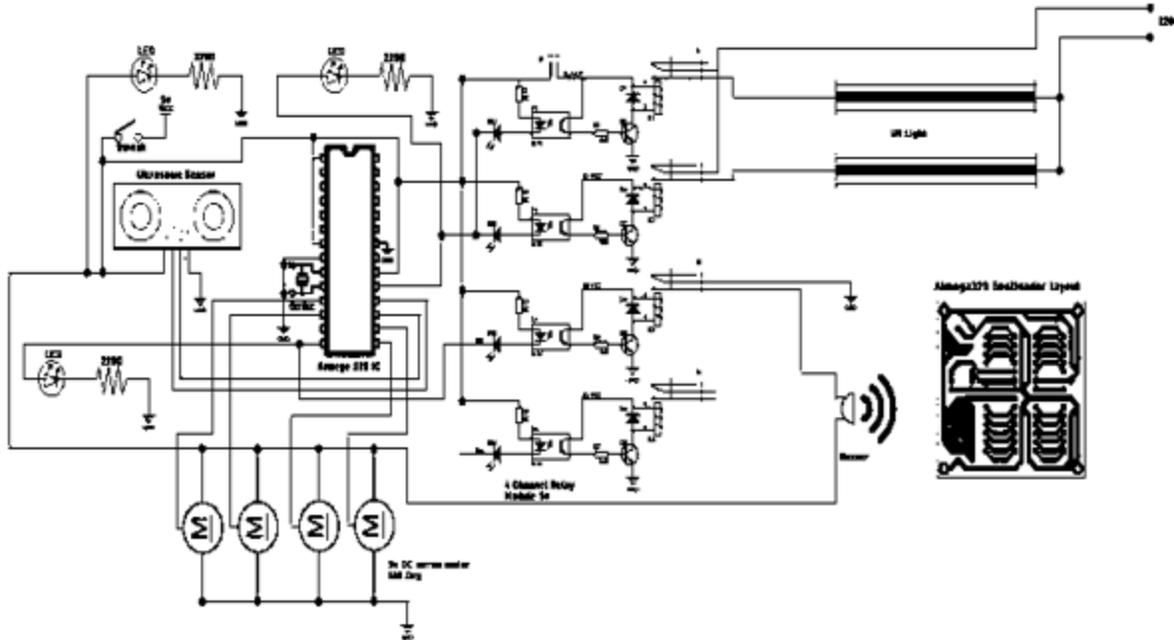


Figure 1. Prototyping Model

The first stage of the process in developing the Microcontroller-based Automated Disinfection Device (MADD) involves the identification of the existing needs, problems and formulating the objectives. After the needs, problems and objectives were clearly identified, the researchers come up with the design of the model which primarily helped them to visualize the final output. This stage is known as the quick design phase of prototyping, at this point, the researchers did the layout of the design of the model and made a sketch where each components of the model would be placed. Also, in this phase the researcher created a circuit diagram design (see figure 2) to describe and show how each component would be interfaced in the circuit board and to other parts of the prototype.



**Figure 2. Schematic Circuit Diagram**

As shown in figure 2, the components of the MADD were interfaced and connected properly. The signal input of servo motors in pairs are connected to ATmega328 microcontroller to open the doors of the device, and the UV lamp and buzzer were connected to the relay module, which is connected to ATmega328 microcontroller to switch it on once the parcel is inside the device.

Software development of the device was also included in building the prototype. The primary function of the program is to initiate the disinfection process by animating the device itself with the help of sensor recognition, ATmega328 microcontroller, and UV light lamp. The program used was C++ using Arduino IDE. Arduino IDE supports programming languages C and C++. The proponents decided to use the C++ among the programming languages supported by Arduino IDE. Studies shows that C++ being one of the programming languages supported by Arduino Programming Language based on performance is way better than C language in terms of speed, compatibility, memory and point of emphasis. The process flowchart that guided the entire process involved within the device is presented in figure 3.

Figure 3 shows that the components involved in the processes were the ultrasonic sensor, servo motors, relay modules and the UV light lamps. The input signal comes from the ultrasonic sensor and it sends to ATmega328. If signal received does not satisfy the condition, it will repeat the loop until the condition satisfies and proceed to the next condition and execute the disinfection.

After the prototype development, the users evaluated the device in terms of its functionality and usefulness when it comes to disinfecting bacteria.

The device is supposed to achieve a 90 to 95% functionality rate. The researchers tested the device's the functionality of the switch to determine whether the sensor responded and recognized the items upfront. During the process of the evaluation, the researcher inspected the device whether the servo motors responded to inanimate the device's doors and observed if the relay module reacts to turn on the UV light and the buzzer. In addition, the researchers observed the LED light indicator to determine if the ATmega328 microcontroller processed the programming language embedded to it and if the UV light is working properly.

The switch was tested if it allowed a sufficient power supply to flow through the device. And then the sensors were tested if they were recognizing the item accordingly. The servo motors were tested if they responded as quickly as one second to open the doors of the device from zero to one hundred degrees

within ten seconds and close after the same time frame. Furthermore, the relay module was tested if it reacted accordingly by switching on and off the UV light and the buzzer. Also, the microcontroller was tested if it controlled the required operations in the system. And lastly, the UV light was tested if it responded properly when the microcontroller sends the signal to the relay module by switching it on.

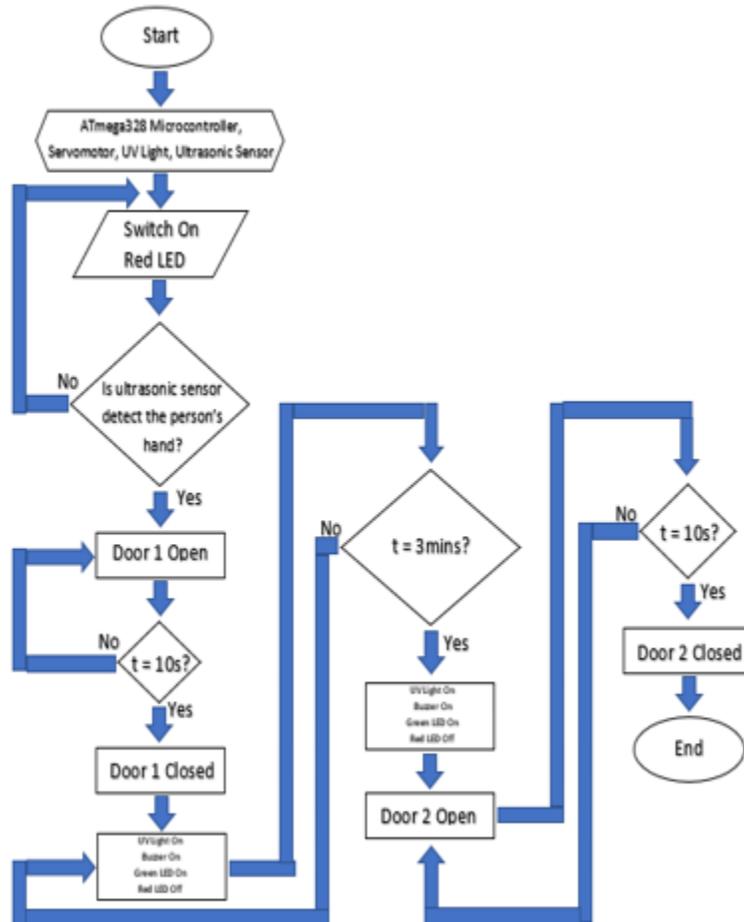


Figure 3. The Process Flowchart

To check the functionality of the system, they conducted multiple tests to validate that the module, sensors, and components of the system were functional.

To determine usefulness of the device in terms of eliminating bacteria in fomites, the third author conducted a bacterial analysis using bacteria gram staining technique before and after the parcel and other objects placed in the device. There were four samples placed inside the device labeled as SP1 for the surface of online shopping bag, SP2 for the surface of a Twenty Peso bill, SP3 for the surface of a ballpoint pen (SP3), and SP4 for the surface of a face shield commonly used as personal protective device to Covid19 virus. The amount of bacteria present in fomites of these samples were tested and compared before and after to establish how MADD is useful in eliminating bacteria in fomites.

After the user's evaluation phase, the prototype was refined. At this stage, suitable adjustments were made based on the results of the evaluation phase. And lastly, in the final stage of the prototype development, the final output was deployed, operated, and maintained for use.

## Results and Discussions

### Microcontroller-based Automated Disinfection Device (MADD)

The developed Microcontroller-based Automated Disinfection Device (MADD) is shown in the figure 4. The prototype is mainly composed of ultrasonic sensor, servo motor, relay, switch, and ultraviolet light. The ultrasonic sensor is interface with the microcontroller, once triggered, it will position the servo motor to ninety degrees, opening the front door. The front door remains open within 10 seconds and close afterwards. After the door closes, the ultraviolet light lamp will be turned on and emit light for disinfection process. Once the disinfection process is done, the back door of the device will open, and the user can pull out the parcel inside the device.



**Figure 4. Microcontroller-based Automated Disinfection Device (MADD)**

### Assessment of the Microcontroller-based Automated Disinfection Device (MADD)

The functionality test used to check the ultrasonic sensor, servo motor, relay module, LED indicators, Atmega328 microcontroller and UV light revealed that these components are functional. Table 1 shows the result of the functionality test performed to the different components of the device.

The results showed that all the components of the MADD gained a positive remark, thus the push button switch, ultrasonic sensor, servo motor, relay module, ATMEGA 328 microcontroller, UV light and the buzzer found in the device were all functional.

Specifically, by pressing the switch on, the device automatically turned on, and when the evaluator pressed the off button, the device automatically turned off. In the actual test, the device successfully detected the hand of the user 5cm away from it. The distance primarily sensible to achieve contact less process when inserting the parcel or products inside the device. In addition, the device did not open when the hand of the user is beyond the 5cm distance from the detector.

**Table 1. Summary of the Functionality Test to the Components of MADD**

Components and Modules	No. of Functional Requirements	Test Case	Remarks
Push-button Switch	1	10	Passed
HC-SR04 Ultrasonic Sensor	1	10	Passed
SG90 Micro Servo Motor	4	10	Passed
4 Channel Relay Module 5v	1	10	Passed
LED	3	10	Passed
ATmega328 Microcontroller	1	10	Passed
UV Lamp	1	10	Passed
Buzzer	1	10	Passed

Furthermore, the actual test shows that the door of the device successfully opened and closed using servo motor from 0 degree to 100 degrees and vice versa. And in terms of the relay module of the device, the actual test shows that the relay module successfully operates and controls the buzzer and UV light by turning it on and off.

The LED light indicator test revealed that the green and red LEDs are turned on and off successfully by the microcontroller. And being the brain of the device, the ATmega328 microcontroller via C++ program, successfully sends signals to the relay module, servo motor, and LED-based on the program. And lastly, during the actual test, the UV light automatically turned on as well as the buzzer when the object is placed inside the device and turned off immediately after three minutes, to completely disinfect the object. Based on the studies, the duration of the exposure of the object under UV light allows to disinfect the object completely.

Since the device is a microcontroller based, it allows MADD to execute sequence of instructions and process that will enable to disinfect fomites of selected samples used in the study. The ATmega328 microcontroller used in the device was able to perform the expected task. The results supported the claim of Hsiung in 1992 that microcontrollers like the ATmega328p microcontroller completely perform specific tasks, such as disinfecting the surfaces of the samples specifically and accurately. Furthermore, the results show how the ultrasonic sensor allows the device to open its door from zero to ninety degrees with servo motor, which able to detect objects at a certain distance, that allows contactless feature of the device.

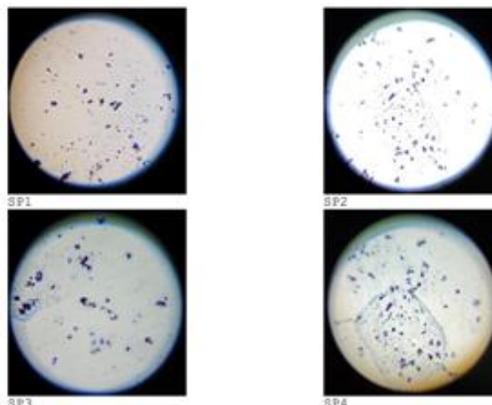
**Usefulness of the Microcontroller-based Automated Disinfection Device (MADD) on Eliminating Bacteria in Fomites**

Results show that the developed Microcontroller-based Automated Disinfection Device (MADD) is useful on eliminating bacteria in fomites.

**Table 2. Results of the Bacterial Staining Technique to the Samples Before Using MADD**

Sample	Presence/Absence	Quantity	Morphology	Type
SP1	Present	Many	rod (bacilli)	Gram +
SP2	Present	Many	spherical (cocci), rod (bacilli)	Gram + Gram -
SP3	Present	Many	rod (bacilli)	Gram +
SP4	Present	Many	spherical (cocci), rod (bacilli)	Gram + Gram -

As shown in Table 2, the surface of the sample materials being tested shows the presence of gram-positive and gram-negative bacterial cells in a cluster/group as elaborated in figure 4.



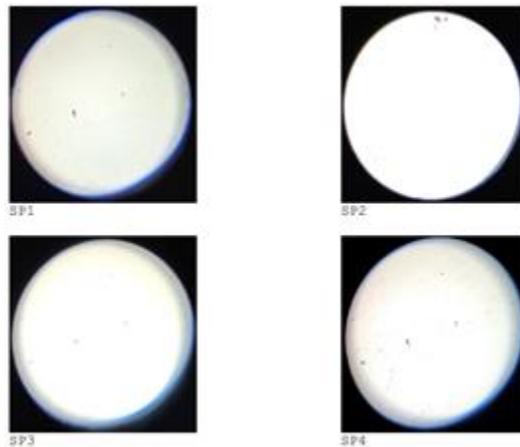
**Figure 4. Bacterial Presence in Fomites of the Samples Before the Use of Microcontroller-based Automated Disinfection Device (MADD)**

On the other hand, Table 3 shows the results of the bacteria gram staining technique on the surfaces of the samples after they were exposed to UV light using MADD.

**Table 3. Results of the Bacterial Staining Technique to the Samples After Using MADD**

Sample	Presence/Absence	Quantity	Morphology	Type
SP1	Present	Few	rod (bacilli)	Gram +
SP2	Present	Few	spherical (cocci)	Gram +
SP3	Absent	None	rod (bacilli)	Gram +
SP4	Present	Few	spherical (cocci), rod (bacilli)	Gram + Gram -

Table 3 revealed that the surface of the sample materials being tested shows a presence to none of mostly gram-positive and some gram-negative bacterial cells in a cluster or group as elaborated in figure 5.



The above results confirm and support previous studies about the use of UV light as germicidal or disinfectant (Reed, 2010). The comparison between the results of the gram staining technique on fomites of selected samples shows that UV lights have germicidal properties, which can eliminate bacteria and microbes (Levetin, et al. 2001). Furthermore, the results confirm that UV light technology can be used for disinfection purposes (Menzies, et al. 2003).

### Conclusion and Recommendations

The study concludes that aside from its present use, the microcontroller is useful when developing a technology like the Microcontroller-based Automated Disinfection Device (MADD), and it can be maximized when it is combined with other devices like the UV light lamp to disinfect fomites of objects that are potential carriers of disease-causing agents. Since MADD uses C++ programming language, it is suggested that using other programming languages may improve the device's efficiency. And lastly, improvement on MADD's over-all design and disinfecting ability is highly recommended.

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