# Implementation of Ultraviolet-type C and Ozone based on Android Home Smartphone for Room and Air Sterilization

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Abstract: The corona virus disease (Covid-19) pandemic has made huge impact on people's lives around the world. One of the solution taken by government to suppress the transmission of virus is through area sterilization. Until now, in many places in Indonesia, sterilization has been carried out using disinfectants. However, this method has been advised to be discontinued because they are carcinogenic, leave odors, and residues. One of the recommended sterilization is to use UV-C light. Although exposure to UV light for long period can be harmful but UV systems in the market these days have been equipped with control systems such as sensors to protect humans and animals. This research is aimed to increase the effectiveness of sterilization through integration of UV-C and Ozone technologies. The addition of Ozone sterilization is aiming to expand the sterilization area especially in places that are not exposed to UV-C light. Through the use of this tool, it is hoped that there will be a break in the chain of virus/microorganisms in the air and in the room. The sterilization system built is controlled from a distance via Bluetooth from mobile phone. The interaction between the cell phone and the sterilization device is carried out through a microcontroller programmed on the Arduino Uno and this sterilization system can be controlled from a mobile phone up to 11 meters. Based on laboratory results, the integration of these technologies can reduce the level of germs in the air up to 90%.

## 1 INTRODUCTION

The Covid 19 pandemic that occurred throughout the world, including Indonesia, has affected human behavior in their daily activities and interactions. The implementation of "New Normal" which by definition is in the form of implementing new habits and behaviors based on adaptation to cultivate clean and healthy living behavior is seriously promoted by the government to reduce the spread of Covid-19 in Indonesia (Kemkes, 2020). Some of the mandatory protocols issued by the government in the implementation of this New Normal are using masks in daily interaction, washing hands more frequent, applying social distancing, and avoiding unnecessary social gatherings. In addition to these protocols, the government has also carried out sterilization of areas or rooms by spraying disinfectants in places that were previously occupied by Covid-19 sufferers. However, the use of disinfectants made of materials such as ethanol, chlorine and H2O2 for sterilization is no longer recommended by World Health Organization (WHO) because it is carcinogenic and triggers microorganism mutations (Sudrajat, 2020)

Some of the recommended ways to sterilize air and rooms are to use Type C Ultraviolet (UVC) light and Ozone. Sterilization using UVC is one of the most recommended methods compared to other methods such as the use of disinfectants and evaporation because it is dry, non residual and it damages microorganisms at the DNA and RNA levels.

UVC Light has a wavelength of 210-310 nm. The levels of ultraviolet effects for organisms and viruses are vary but are efficient for sterilization in the air and rooms. Ultraviolet energy radiation can cause cell damage to microorganism at a crucial level. More than 3 decades, a number of studies have shown that ultraviolet radiation can block DNA and RNA polymerase which results in inhibition of DNA strain replication and transcription. Air and room sterilization using UVC in an area of 1 m3 is able to reduce almost 90 percent of microorganisms scattered in the air (M. Bentancor & Vidal, 2018).

Even though the use of UV-C is considered very effective to reduce microorganisms in the air, but for indoor use, only the exposed area is sterilized. Therefore, the ozone sterilization method is



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considered to be able to complete the UV-C sterilization process because Ozone gas is able to help sterilize areas that are not exposed to UV-C light (Cahyadi, 2020).

Ozone gas can function as a cleaner, deodorizer and as a disinfectant that is able to kill all microorganisms such as bacteria, viruses, fungi, seeds. Ozone is the second most powerful oxidizing agent after fluorine, and when compared to chlorine, ozone's ability to disinfect is 3250 times faster and its oxidative power is 50% stronger. Given the benefits and advantages of ozone, it is not surprising that ozone is still being used to sterilize water, air and foodstuffs, so that apart from being durable, it is also safer to consume. Ozone before or after reacting with other elements will always produce oxygen so that ozone technology is very environmentally friendly or it is often said that ozone is the future green chemistry. (Agus Purwadi, 2003).

With the addition of ozone, sterilization on hollow surfaces or in places / surfaces that are not exposed to UV-C light can still be carried out effectively. When compared to disinfectants, sterilization with Ultraviolet and Ozone gas is considered safer because it does not involve chemicals, has no residue in its use because it only uses light exposure, and does not cause odors to the object or area being sterilized. Although UV-C has advantages compared to chemical disinfectants, the use of UV-C can also be harmful to humans because it can trigger cancer through radiation in long-term use. Exposure to UV-C radiation as the type of UV with the greatest energy can damage human DNA when exposed directly and for a long time (Faturrohman, 2020). Therefore, in its use, it must be isolated from human existence. Currently, there are many UV-C sterilization technologies that have been sold in the market, especially during this pandemic. The technology can be in the form of a UV-C sterilization box, and UV-C lamps that are equipped with motion sensors that are able to detect the presence of humans when they are around the sterilization area.

Even though UV-C and Ozone sterilization technologies on the market are generally equipped with motion sensors to protect humans and pets from radiation when entering the sterilization area, according to the authors, the addition of remote control is considered important and necessary to provide extra protection and convenience in operating the technology. One type of remote control that is convenient to implement is smartphone applications as smartphones have become an inseparable part of daily activities. With this android-based remote control, the possibility of users (humans) being exposed to UV radiation in sterilization will be smaller.

Most common sterilization systems on the market today are equipped with only PIR sensors to protect humans and pets from exposure to UV-C rays. Although there has been control using Bluetooth, but this control is done via remote control.

Control with the Android home Smartphone system has not been carried out on the UV sterilization system that has been integrated with the Ozone generator. So far, control has only been carried out on the UV-C 254 nm system (Eko Joni Pristianto, 2020), so that for areas that are not exposed to light, sterilization cannot be done so that it is less effective in breaking the chain of spread of microorganisms, especially viruses.

In making a control system involving an Android smartphone, one way to move the target system is to use an Arduino Uno which is equipped with a Microcontroller in the system. The media used for communication between the Smartphone and the Arduino microcontroller is via Bluetooth.

## 2 METHOD

This applied research aims to increase the effectiveness of sterilization to reach areas that are not exposed to UV-C light through the integration of UV-C technology and Ozone Generator. Moreover, through the addition of a control system based on the Android Home System, it is hoped that it can provide protection to human health during the sterilization process. The research stages are as follows:

1. Literature Study and System Planning

The main purpose of this stage is to identify the problems and to get the design of proper sterilization system to answer the existing problems.

2. Determining System Requirements

At this stage, an analysis is carried out on the need for tools to build a UV-C and Ozone sterilization system based on Androidhome Smartphones.

3. System Construction

At this stage, software and hardware are designed to produce a UV-C and Ozone Sterilization System with Androidhome Control. At this stage, hardware and software are built and then integrated through the microcontroller.

4. Testing

This stage is aiming determine whether the system works according to the design or not. At this stage, two types of tests are carried out, namely testing the work of the tool and testing the impact of the work of the tool (air quality testing).

5. Final Result

The final result of this research is a UV-C Ozone Sterilization System based on Androidhome Smartphones that can be used to sterilize the room and air.

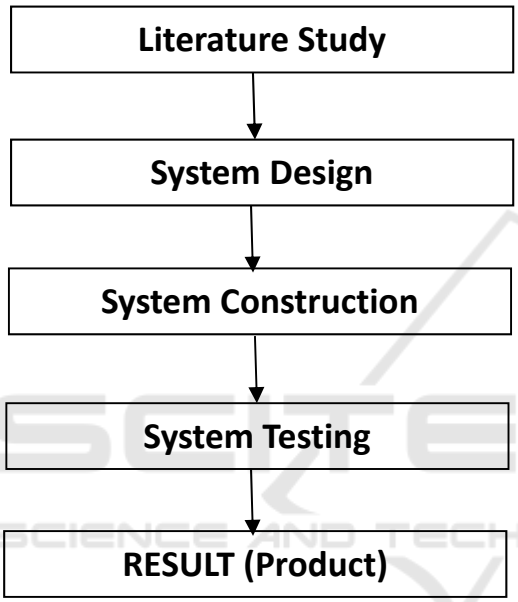


Figure 1: Research Flow.

## 2.1 Hardware Design and Construction

Based on the problems that have been described previously, the system built must meet the following objectives:

a. Sterilization Devices (UV-C lamps and Ozone Generators) are wirelessly able to connect/communicate with android smartphones via Bluetooth devices.

b. The system is able to control the lights remotely through android device.

Some of the subsystems built on the hardware are:

a. Supply System to power the Sterilization Device

b Control System, to control the operation of the Device

Some of the device components used for the systems are:

- Arduino Uno
- Bluetooth HC-05
- Relay Module 4 Channel
- Servo
- UV-C Lamps
- 12 Volts Power Supply
- Ozon Generator
- Lamp Fittings and Cables

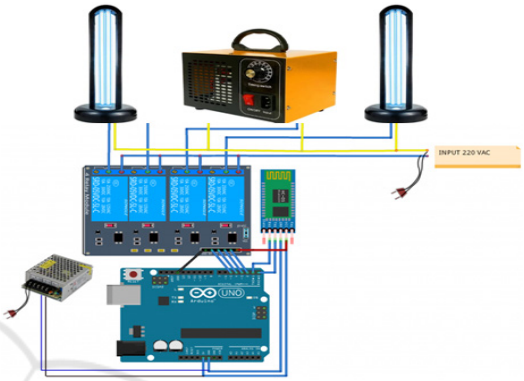

Figure 2: Circuit System.

## 2.2 Software Design and Construction

The application built on the android system aims to control the sterilization system via bluetooth.The components to be controlled in the system include 3 UV-C lamps and an ozone generator. Programming process is done in C Language and the version of the Android used for the system is Android Ide 8.5. Some of the features that must be built into the software are:

- Connection Button to connect the software and hardware via Bluetooth
- UV-C and Ozon Generator Buttons Controls.

## 2.3 Testing

There are 3 types of tests carried out on the system, namely a software and hardware connection test, a distance test and a germ level test in the room.

- Connection Test is aiming to exercise whether the control system works as commands from smartphone. The control system should be able to activate and deactivate UV-C Lamps and Ozon Generator from certain distance
- Distance Test is aiming to test how far the system can be controlled.
- Laboratory test is aiming to test germ's level in the air before and after sterilization. This test will be run in several points to measure the

effectiveness of the system in reducing the germ's contamination in the air.

# 3 RESULTS

## 3.1 Hardware

The hardware of the system consists of sterilizing components (UV-C Lamps and Ozone Generator, system supply and control system). The hardware of the system can be seen in the figure below

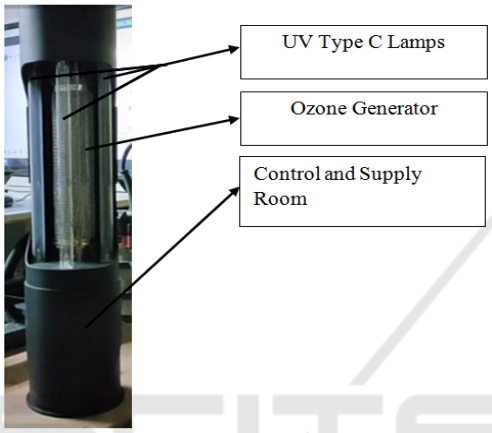


Figure 3: System Hardware.

## 3.2 Software

The android application built consists of several command buttons such as

a) Bluetooth Button

This button serves to connect the Android system on the cellphone with the system hardware.

b) UV-C Buttons

This button functions to control the number of active UV-C lights on the hardware system.. The number of active lights will be displayed on the button label

c) Ozone Duration Buttons

This button serves to control the working duration of the Ozone generator. The duration consists of 10 seconds, 30 seconds, 60 seconds and 120 seconds.

d) "Cancel Ozon" Button

This button serves to stop the work of the Ozone generator.

The display of the software built can be seen in the figure below:

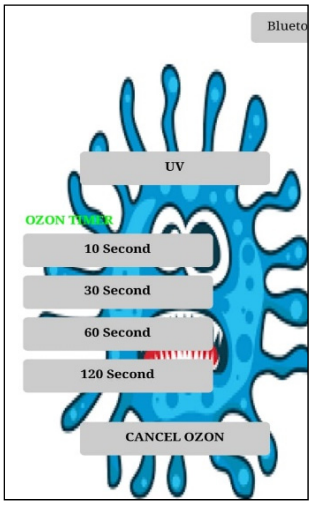


Figure 4: System Software.

Some of the system programming is shown in the figure 5.

```
tesdata
int data = 0;
int uv1 = 5;
int uv2 = 6;
int uv3 = 7;
int ozon = 8;
char received;
int stopozon = 20;
int x = 0;
void setup(){
  Serial.begin(9600);
  pinMode(uv1, OUTPUT);
  pinMode(uv2, OUTPUT);
  pinMode(uv3, OUTPUT);
  pinMode(ozon, OUTPUT);
  digitalWrite(uv1,HIGH);
  digitalWrite(uv2,HIGH);
  digitalWrite(uv3,HIGH);
  digitalWrite(ozon,HIGH);
  //Serial.print("OK");
  //Serial.println();
  delay(100);
  }

void loop(){
if(Serial.available()>0){
    data = Serial.read();
    char Rec = char(data);
if (Rec != '0'){
    Serial.println(Rec);
    }
```

Figure 5: Software Programming.

## 3.3 System Testing

1. Connection Test

The result shows that the communication between the applikasi in the mobile phone and the hardware system works as desired.

Some of test results are shown in the figures below.

Figure 6: System Pairing.

Figure 7: Activating 1 UV-C light and Ozone Generator.

Figure 8: Activating 3 UV-C lights and Ozone Generator.

## 2. Distance Test

The control range of the sterilization system built can be seen in the table below.

In testing the connectivity of the Android system to the sterilizer, the room size is 8 x 14 $m^2$ with several partition /cubicles (3 rooms). The presence of these cubicles can contribute to the effectiveness of the connection.

Table 1: Distance Range of the Bluetooth Connection Of the System Build.

| Distance (meter) | Bluetooth Status |
|---|---|
| 1 | Connected |
| 2 | Connected |
| 3 | Connected |
| 4 | Connected |
| 5 | Connected |
| 6 | Connected |
| 7 | Connected |
| 8 | Connected |
| 9 | Connected |
| 10 | Connected |
| 11 | Connected |
| 12 | Not Connected |

## 3. Laboratory Test

The Germ level test is applied in this research to measure how effective the system in reducing the level of the Germ in the air.

The location of the test is located in Electrical and Engineering department of the Polytechnic Negeri Kupang. Germ level testing was carried out in two types of rooms, namely the Meeting Room and the Lecture Room (TEB). The size of Meeting Room is 8 x 10 $m^2$ while the lecture room is 6 x 8 $m^2$. In the meeting room, the location of the sterilizer is tested at 3 points, namely point A (center), B (left side of the room), and C (right side of the room).

Meanwhile, in classrooms, the position of the sterilizer is only in the center of the room.

During the test, all the ventilation are closed to reduce air circulation. The System was operated for 5 minutes for each point during sampling process.

Figure 9: Test's Sampling.

The result of the effectiveness of the system is shown in table below.

Table 2: Laboratory test results.

| Room | Germ Level (CFU/m$^3$) | | Percent of Reduction |
|---|---|---|---|
| | Before | After | |
| Meeting Room (Point A) | 25 | 2 | 92% |
| Meeting Room (Point B) | 6 | 0 | 100% |
| Meeting Room (Point C) | 5 | 0 | 100% |
| TEB 1 | 30 | 3 | 90% |
| TEB 2 | 34 | 2 | 94% |
| TEB 3 | 42 | 3 | 93% |
| TEB 4 | 40 | 4 | 90% |
| TEB 5 | 38 | 2 | 95% |

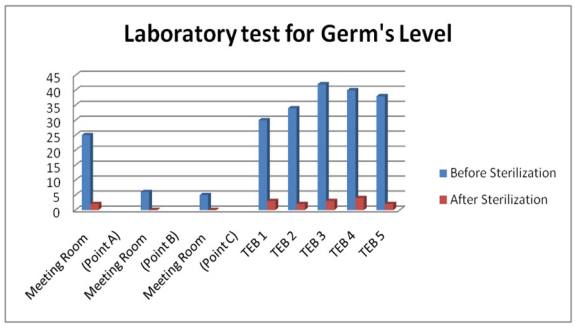


Figure 10: Germ level reduction.

From the table and the chart above, the effectiveness of the system is very high. In meeting room, the reduction of germ in the air is very significant. From 25 CFU/m$^3$ is reduced to 2 CFU/m$^3$. For TEB Rooms, the level of germs decrease significantly to below 5 CFU/m$^3$. The average reduction level of the germs is more than 90%.

## 4 CONCLUSION

The System built in this research is aimed for air and room sterilization, especially during Covid 19 pandemic era. This system is an integration between UV-C 254 nm technology and ozone generator. The system built is safe and practical to use because it protects human or pets from the exposure of UV as the system is controlled from a distance via bluetooth from mobile phone. The interaction between the cellphone and the sterilization device is carried out through a microcontroller programmed on the Arduino Uno and this sterilization system can be controlled from a mobile phone up to 11 meters in a areas with room partitions. Based on laboratory results, the effectiveness of this system in reducing the number of germs in the air is above 90% in the 8 x 10 and 6 x 8 rooms with minimum air circulation condition where all air vents are closed.

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