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Prototype of Air Neutralizer Equipment Based on Temperature Sensor and Dust Particle in Reducing the Number of Bacteria in Bedrooms of Tb Patients in the Johar Baru Puskesmas Region-Central Jakarta

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***Abstract*—Tuberculosis cases continue to increase, so in eliminating TB cases, the right way must be sought and have high leverage. Stopping airborne transmission is an action that can be done quickly. This research has developed a prototype of a "room neutralizer", which can kill microorganisms in the air. The DS18b20 sensor is used to detect temperature and the GP2Y1010AU sensor detects PM10 dust particulates, the Arduino Uno as the Main Control Unit is displayed with an LCD. The working principle of the tool when detecting temperature and dust particles in the high air will suck in air and pass it through the HEPA filter and closed UV lamp which is then removed again. Trials were carried out in 20 bedrooms of TB patients with an air neutralizer placed for 24 hours, and the number of germs was measured before and after the device was installed. It was found that the tool was able to reduce the number of bacteria up to 76.79% and reduce the number of fungi to 96.97%, but there was no difference in the ability to reduce the number of bacteria and fungi (sig> 0.05) before and after the air neutralizer was installed.**

Keywords*—*prototype air neutralizer, air quality, number of air microorganisms

I. Introduction

In 2018 WHO report, it was written that TB cases in Indonesia reached 842 thousand. The number of cases of tuberculosis, Indonesia was the world's third largest after India's 2.4 million cases, and China 889 thousand cases, where there will be one person infected every 30 seconds and 13 deliver their lives every single jam [1]. Riskesdas 2018 data shows that the prevalence of pulmonary TB based on a doctor's diagnosis for Indonesia is 0.42% but for DKI Jakarta 0.51% [2]. Referring to BPS data for 2018 [3], the population density for DKI Jakarta Province is 15.7 thousand / square km, and the second most populous area is in the City of Central Jakarta at 19.1 thousand / square km. The area of Johar District is only 46.1 thousand/Km or 46 people /m. According to data from the Johar Baru Puskesmas, there are 200 new TB cases per year.

The source of tuberculosis transmission is TB patients with positive smear, when sneezing or coughing the patient will spread nearly 20,000 droplets containing germs into the air [4]. A person with active TB or who is still shedding TB bacteria from their droplets is a source of infection for the environment. So, stopping the main transmission through the air entering through the respiratory tract is an action that can be done quickly. Poor physical quality of indoor air, such as humidity, high temperature, and dust concentration, and low ventilation area can facilitate airborne transmission, thus improving the physical quality of indoor air can reduce the number of microbes in the air so that it will reduce transmission. This high population density causes minimal air exchange, as a result, the accumulation of chemical and biological pollutants in the indoor air will occur. This will accelerate TB transmission cases. Besides, the house that is squeezed will make it difficult for sunlight to enter the room so that microbial contamination in the room can last longer and accumulate, which later becomes a potential source of infection.

This study aims to obtain an air neutralizer that can reduce the number of airborne bacteria in the bedroom of TB sufferers and analyse the physical quality of the air (temperature, humidity, ventilation rate, and occupancy density) and the number of dust particles in the room of TB patients before and after using air neutralizer.

II. Material and Methods

A. *Assembling the Air Neutralizer Prototype*

The prototype is based on research by Handayani and Ma'murorun [5]. Prototype tool "neutralizer", which can kill microorganisms in the air. This tool uses a temperature sensor and dust particles. The working principle of this room air neutralizer will be active when the temperature and dust particle sensor reads these variable passes the threshold, then the air will be sucked in and passed through the HEPA filter and closed UV lamp which is then removed again to the air. This tool can activate itself by reading indicators of temperature increases and the number of dust particles in the air (Figure1).

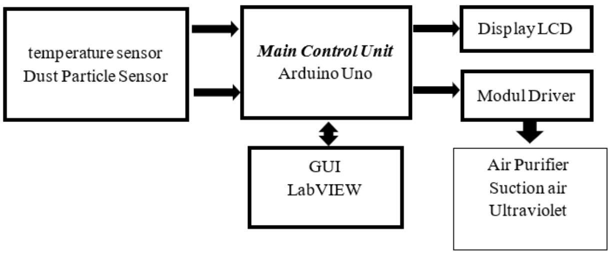

Fig. 1. Working chart prototype air neutralizer.

1) Temperature sensor: The DS18B20 sensor is issued by Dallas Semiconductor which is a digital sensor that has an internal 12-bit ADC. DS18B20 temperature sensor operates at a temperature of -55 ˚C to + 125 ˚C. The advantage of the DS18B20 is that the output is in the form of digital data with an accuracy value of 0.5˚C for a temperature range of 10˚C to + 85˚C, making it easier to read by the microcontroller. For temperature readings, this sensor uses a one-wire communication protocol and has 3 pins consisting of + 5V, GND, Data Input / Output [6].

2) Dust sensor: GP2Y1010AU0F Optical Dust Sensor is an infrared-based dust sensor. These sensors are very effective at detecting very fine particles such as dust or cigarette smoke and are commonly used in air purification systems. The working principle of this sensor is to detect dust or other particles and then the light will be reflected the receiver. Light is reflected on the particles across the entire surface, then converted by photodiode into voltage. The voltage must be amplified to be able to read the changes. The output from the sensor is an analog voltage proportional to the measured dust density, with a sensitivity of 0.5V / 0.1 mg / m3. To be able to convert analog data to 10-bit digital data, equation (1) is used as follows:

$$\text{call voltage} = \text{voMeasured} * (5.0/1024) \qquad (1)$$

Furthermore, to convert digital data into a dust exposure concentration value equation (2) is used as follows:

$$\text{dustDensity} = 0.17 * \text{calcVoltage} - 0.1 \qquad (2)$$

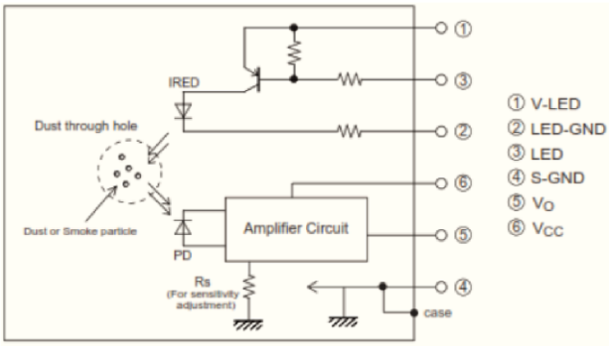

Fig. 2. Internal schematic dust sensor GP2Y1010AU0F [7].

3) Arduino uno: Arduino Uno is the latest version of the Arduino family, based on the ATmega328 microcontroller, with the following hardware specifications.

- Microcontroller: ATmega328
- Operating Voltage: 5 V
- Input Voltage: 7 - 12V
- Digital I / O: 14 pins
- PWM: 6 channels
- Analog Input: 6 channels
- Memory: 32KB Flash PEROM (0.5 KB used by the bootloader), 2KB SRAM and 1KB EEPROM
- Clock Frequency: 16 MHz

The Arduino can be used to develop interactive objects, take input from various switches or sensors, and control various lights, motors, and other physical outputs. Arduino IDE (Integrated Development Environment) software is a software that makes it easy to develop microcontroller applications from writing source programs, compiling, uploading compilation results, and testing serial terminals. The data communication relationship between the Arduino IDE and the Arduino board is used serial communication with the RS232 protocol.

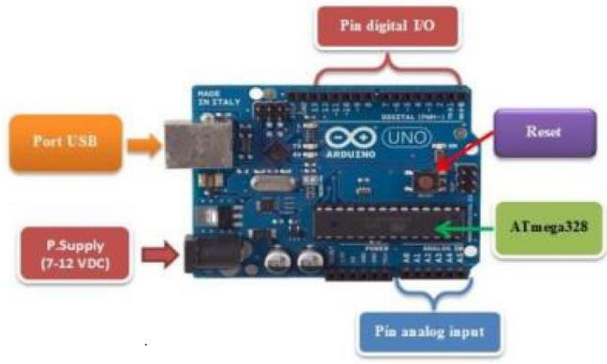

Fig. 3. Board Arduino uno.

4) LabVIEW: LabVIEW is a programming language produced by National Instruments based on graphics using icons instead of text to create applications. LabVIEW is also called a Virtual Instrument (VI). VI contains three components, namely the front panel, block diagram, and icon and connector panel [8]. It also simplifies hardware integration so you can quickly acquire and visualize data sets from almost any I / O device.

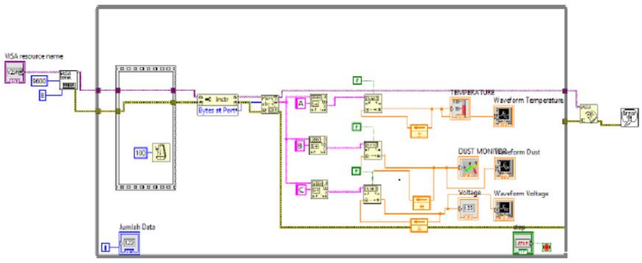

Fig. 4. System diagram blocks with LabVIEW.

This tool is placed in the bedroom of TB sufferers for 48 hours, in an active condition.

B. *Measurement of Air Physical Quality*

Measurement of air temperature and humidity with a Termohygrometer, tools placed in the bedroom for 48 hours.

C. *Dust Particle*

Inspection using Low Volume Sampler (LVS) with flowrate 10 litres per minute for 1 hour, using filter paper pore diameter 0.45 microns.

D. *Air Bacteria Quality*

Check is done by capturing air bacteria using Trio Bas tool, with a speed of 500 Lpm for 10 minutes, which is spread on blood media in order, which is then incubated for 24-48 hours and calculated colonies of growing bacteria (CFU/m^2).

E. *Population and Samples*

The air in the bedroom of TB patients' homes in the working area of Puskesmas Johar Baru, which was previously obtained from the data of TB forms 01 examination results from June to August 2020 as many as 24 patients. The sample is the total population, there are two houses with two sufferers each, two people are not willing as respondents, then there are only 20 bedrooms as a sample.

III. Result and Discussion

The air neutralizer prototype designed has dimensions of 20x20x50 cm2 (Length x Width X Height) with sensors for temperature and the number of dust particles, touchscreen buttons, and only 6V of UV intensity electricity used. This tool also uses a supply of electrical energy in a 60-Watt installation then it will be stable at 50 Watt.

Fig. 5. Prototype air neutralizer.

According to Permenkes No. 1077 / 2011 [9] on Guidelines for Air Sanitation, factors that will affect the quality of the house include occupancy density, temperature, humidity, lighting, and ventilation area. After measuring the physical quality of the air in the bedroom of a tuberculosis patient, it was carried out. The following results were obtained:

A. *Occupancy Density*

Measuring occupancy density is measured by the number of people who use the room as a sleeping space for at least 4 (four) hours a day, with the category of eligibility if ≤ two people per 8 m2 of the room area.

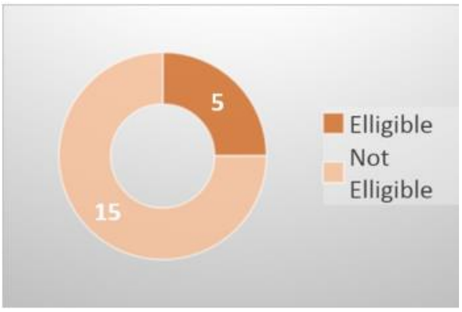

Fig. 6. Bedroom density of TB patients in the working area of the Puskesmas Kec. Johar Baru Central Jakarta, 2020.

A compact bedroom has the potential to facilitate the transmission of microorganisms from TB sufferers to other people who sleep in the same room. According to Ryan and Ray [10], About 25 to 30% of healthy people carry microorganisms as either resident or transient flora at any given time. The organism may spread to other skin sites or by droplet spread during an upper respiratory infection. The nasopharynx has a flora like that of the mouth; however, it is often the site of carriage of potentially pathogenic organisms such as Pneumococci, Meningococci, and Hemophilus species.

B. Temperature

The results of measuring the room temperature of the bedrooms of TB patients found that all rooms had a temperature of > 30^{0}C, with an average indoor temperature of 29.1^{o}C. and temperatures outside 33.05^{0}C, most of microorganism life optimum between 20 and 45^{0}C (mesophiles) [11]. The high temperature can occur because of the density of the occupancy in the room. The negative impact that occurs is the easy transfer of microorganisms from TB sufferers to other family members. This can be reduced by increasing the ventilation rate in the room. For example, by adding windows or reducing furniture in the bedroom, so as not to disturb/hinder air movement.

C. Humidity

Measurement of the room humidity in the bedroom of TB patients for 48 hours, the results are as follows:

TABLE I. RESULTS OF MEASUREMENT OF THE BEDROOM HUMIDITY OF TB PATIENTS IN THE WORK AREA OF THE JOHAR BARU DISTRICT HEALTH CENTER, CENTRAL JAKARTA, 2020

Moisture Value	Total
<40%	0
40-60%	4
>60%	16
Total	20

From the data in table 1, most of the bedroom space has humidity> 60%, this will simplify and accelerate the growth of microorganisms. The high humidity in most of these rooms is because the houses are close together so that sunlight can enter the room, and it unites the bedroom with other activities, such as the kitchen or bathroom.

D. Lighting

The high-density level and low socioeconomic level for most of the respondents who made them only provided lighting in the front room or kitchen, so that the bedroom was rather dim, so only 5 respondents' rooms had lighting> 60 lux.

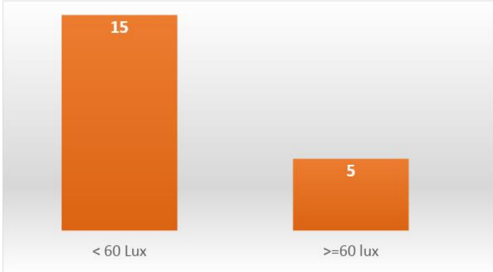

Fig. 7. Results of measurement of lighting in bedrooms with TB patients in the Puskesmas Area, Kec. Johar Baru Central Jakarta, 2020.

E. Dust Particles

Total Suspended Particulate (TSP) or Suspended Particulate Matter (SPM) is a very complex mixture of various organic and inorganic compounds from those having sizes below 1 micron to 500 microns [12]. Total Suspended Particulates is dust that remains in the air and does not easily settle and float in the air.

In the figure 8, the total level of dust particles in the room air of TB patients, before installing the air purifier is at least 0.04 mg / m3 and at most 0.59 mg / m3, after installing the air purifier for 48 hours It was found that the total dust particles were at least 0.01 mg / m3 and at most 0.59 mg / m3. There are rooms that have decreased in 10 bedrooms, with the largest decrease of up to 97%. But there are also rooms where the number of dust particles has increased by up to 86%, originally only 0.08 mg / mm3 to 0.59 mg / mm3.

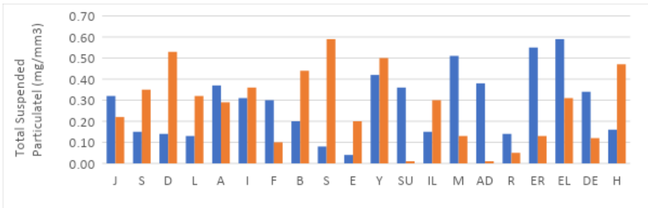

Fig. 8. Dust particle levels (mg / mm3) before and after air neutralizer installation.

From the difference test with the Paired sample test, it was found that the sig value was 0.86> 0.05 at the 95% confidence level, there was no difference in the total levels of dust particles in the air before and after the appliance was installed. This happens because the presence of dust in a room is influenced by many factors, in addition to the density of the occupancy, the rate of ventilation, the amount of items/furniture in the room that is a source of dust, and the level of cleanliness of the room. Also, it can occur because the suction power of the tool is not too big so that the air being cleaned is not optimal.

F. The Number of Microorganisms in the Air

Air microorganisms are obtained by sucking the air with the Biological Air Sampler Trio. Bas has two Petri dishes. With a suction power of 200 lpm, carried out for 1 minute. The medium used to catch bacteria is blood agar. From the results of planting on the number of bacterial colonies that meet the following requirements:

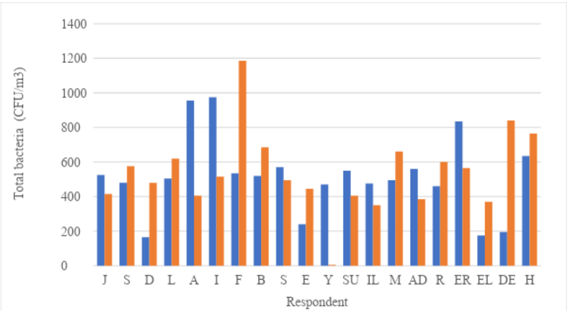

Fig. 9. Number of bacterial colonies (CFU / m3) in the bedroom Air of TB patients before and after installing air purifiers.

There are 9 rooms where the number of airborne bacteria has decreased, with the lowest percentage of 20.95% and the highest to 98.94%. But 11 rooms experienced an increase in the number of bacteria, with the smallest percentage being 16.52% and the highest being 76.79%. The air neutralizer has not been able to control the number of bacteria present in the air in the bedroom, it is also proven by statistical calculations with 95% confidence that the sig number is 0.763> 0.05, meaning there is no difference in the number of bacterial colonies before and after the appliance is installed.

There is no difference in the number of bacteria and fungi after installing the air purifier, possibly due to several factors: 1) The suction power of the tool is small, so it is unable to eliminate these microorganisms; 2) The level of occupancy density is very high so that the number of contaminants is very high and continues to exist; 3) The humidity of the air is very high so that it can accelerate the growth of microorganisms optimally; 4) The location of the air purifier is too low so that it is unable to suck up the droplets that are still left in the upper air.

IV. CONCLUSIONS

That the air neutralizer has not been able to significantly reduce the number of air microorganisms. Need to be developed the next generation by elevating suction ability and smaller size to be hung on the wall.

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