The Application of Ergonomics in the Design of Air Filtering Devices Through Software Engineering

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Abstract. Air is a part of an important element in life, with the aim that all living things can move optimally. From this everything needs to get quality air, so that the inhaled air feels healthy and fresh. Lately, air problems are very much discussed, especially in urban areas that produce many pollution from various sources produced. Air pollution is one of the activities that produce air quality inappropriate as it should, and is contaminated with hazardous substances for living things. This research has the aim of applying ergonomics in the design of air filtering devices through software repair. In this study, applying analyze, design, development, implement, and evaluate (ADDIE) model. Each of them focuses on the design of the tools carried out: Analyze identifies the problems that occur, especially in the air quality which lately is widely discussed. Design of designing tools that have stages: vacuum cleaner, washable pre filter, activated carbon deodorization filter, dust collecting filter, and internet hardware of things. Development carried out the development that will be carried out, which is integrated with the Internet of Things (IoT) in the form of application. Implement in the application of air filtering equipment, namely in the housing, shopping, and places of dismissal sectors. Evaluate conducts testing that will be known to the strength of the tool, by paying attention to several previous references. The results of this study will produce an air screening tool through software engineering, namely Sketchup software. Some literature studies show air filtering with some tools used will make the dirty air clean air. Some categories and range of standard levels of Particle Metter (PM) 2.5 and Standard Air Freight Index (ISPU): Good (1-50), Medium (51-100), Unhealthy (101-200), Very Unhealthy (201-300), and dangerous (301-500). The conclusion in this study results in a design of air filtering tools that can be applied on the roof of the house, shop, and others. This has the goal so that the results of dirty air above will be filtering and producing clean air. So that the air inhaled around the building with the tool will feel healthy and fresh.

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1 Introduction

Air pollution is an environmental problem that is universal and occurs throughout the world. Referring to data from the World Health Organization (WHO), air pollution can result in premature deaths that have reached 2 million people per year. In 2005, WHO made the 2005 WHO Air Quality Guidelines (AQGS) which was designed to reduce health problems due to air pollution [1]. In AQGS, recommendations for reviewing restrictions for air pollution concentration have been given. Like Particulate Matter (PM), Ozone (O3), Nitrogen Dioxide (NO2), and Sulfur Dioxide (SO2). Air pollution is sourced from natural processes and human activity, moving, or not moving. Most problems in urban air pollution are sourced from the use of fossil fuels and industrial activity. Industrial activities provide various kinds of air pollution, depending on its industrial activities. Likewise with urban areas, which picked up various air pollution that depends on their activities [2]. The following is the concentration of PM2.5 in the ASEAN country's air (2022), in Figure 1. below.

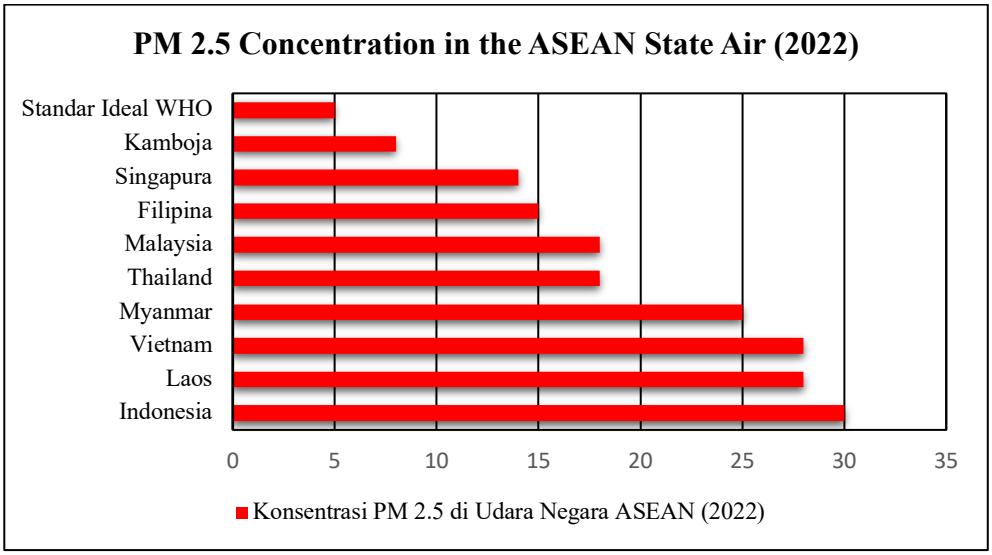

Fig. 1. PM 2.5 Concentration in the ASEAN State Air (2022) [3]

Particulate Matter (PM) affects many public health rather than other pollution. The largest components of PM consist of sulfate, nitrate, ammonia, sodium chloride, carbon, mineral dust, and water. PM consists of a mixture of solid and liquid particle complexes, organic and inorganic substances in the air. The particles are identified based on their aerodynamic diameter, namely PM10 (particles with small aerodynamic diameters of 10 μm) and PM2.3 (small aerodynamic diameter of 2.5 μm) [4, 5]. Sources of particulates include transportation (all land transportation to display PM10, but Diesel vehicles are drawing more), mixing and use of fertilizers and pesticides, construction, industrial processes such as manufacturing of iron and steel, urban areas, burning of agricultural residual (straw), and forest fires. The results of ambient air monitoring data in 10 major cities in Indonesia show that PM10 is the most frequent parameter as a critical parameter (Bapedal, 2000, 2001; KLH, 2002, 2003, 2004). According to data from clean emission partners, air pollution due to five pollution materials is above the threshold. Among these, the maximum number of daily PM10 pollution reaches 496.22 μg/m3 (with a quality standard 150 μg/m3) [6, 7]. The following is the concentration of PM2.5 in the air as big cities in Indonesia (2022), in Figure 2. below.

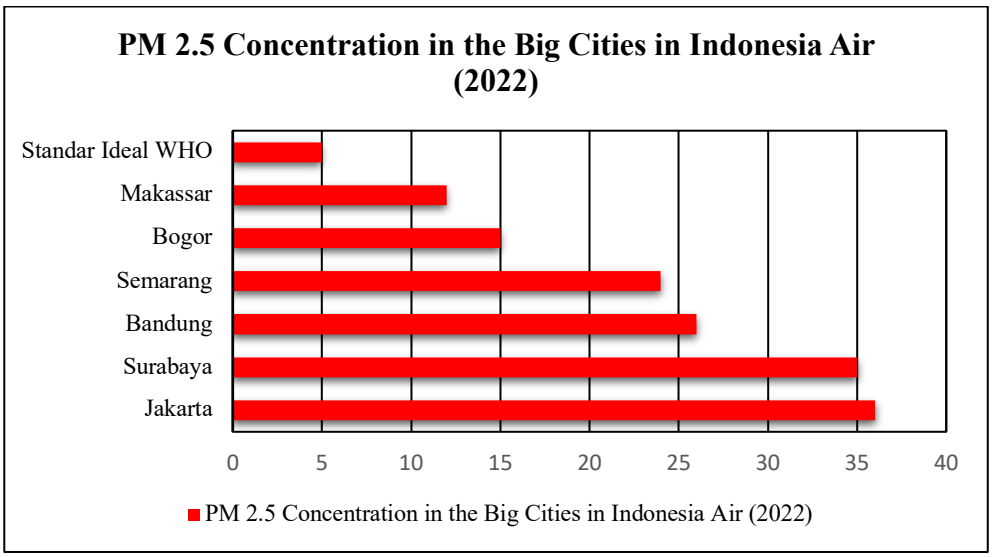

Fig. 2. PM 2.5 Concentration in the ASEAN State Air (2022) [3]

The following are some of the results of previous studies that discuss the problem of air pollution, as in Table 1. State of the Art below.

Table 1. State of the Art (SOTA)

No	Title	Previous Research
1.	Design of Emission Gas Absorption and Cleaning Tubes	The results of the research carried out were the design of a tool that resulted in the calculation of the Honda Supra Fit reducing carbon monoxide emissions by up to 65.7%, carbon dioxide by 66.7% and hydrocarbons by 63.7%. These results are not much different from tests on the 2008 Honda Vario motorbike. The ability of the emission cleaning tube to absorb exhaust gases, such as carbon dioxide, is quite good. This can be compared by referring to the permitted carbon dioxide emission standard of 5.50% [8].
2.	Design an IoT-based device for neutralizing cigarette smoke levels in a room	2. Based on the test results, this tool is able to detect the level of cigarette smoke collected in a room accurately, and takes ±8 seconds to neutralize a room contaminated with cigarette smoke above 5 ppm and takes longer ±15 seconds for cigarette smoke >10 ppm to become smoke-free room [9]
3.	Design Optimization of Portable Hepafis Plasma Air Purifier Using UVC Rays to Reduce Indoor Pollutants	The results of air quality pollutant testing are known for normal room air from 100 ppm to 46 ppm and smoky room air from 334 ppm to 46 ppm where the room air is good for humans according to the Air Pollution Standard Index. Furthermore, for the bacterial number values resulting from laboratory checks from the test results for 30 to 120 minutes, the bacterial number test results have met the quality standard limit, namely below 500 cfu/m3, the test results are 188 to 44 cfu/m3 so that the plasma hepatic testing machine using UVC has an effect on reducing bacterial numbers [10].
4.	Design and Build a Microcontroller-Based Automatic Ventilation Cover and Air Cleaner	The results of the research carried out are an air cleaning system consisting of a DC fan which is turned on by a relay which will rotate to remove dirty air. This tool is equipped with a buzzer as an alarm, an LCD to display the concentration of each gas and a green and red LED which will turn on when the air is clean and

No	Title	Previous Research
	Control System Prototype	dirty. The MQ-135 sensor and MQ-7 sensor that have been characterized can measure CO2 and CO concentrations with error percentages of 1.48% and 3.53%, respectively. Test results show that the system prototype is able to measure CO2 and CO levels in dirty air conditions with the highest measured concentrations being 1544 ppm and 9 ppm, the servo motor is able to close the ventilation and the DC fan expels dirty air [11].
5.	Internet of Things-Based Indoor Air Quality Monitoring System Design	The final result of the tool created is that the tool will detect if there is pollution. The real time sensor reading results are then sent via the WiFi module to the Internet of Things OVoRD (Online Value of Real Time Data) platform and displayed in an easy-to-read web form. This system has the potential to be used as an indoor air quality monitoring system to increase awareness about the importance of healthy air quality [12].
6.	Capability Of Air Filtering Devices With Banana Mid And Zeolite Media To Reduce Carbon Monoxide (Co) Levels In The Air	The results of the research can be concluded that: The carbon monoxide (CO) level before passing through the banana stem and zeolite filter media was 60 ppm at the first point and 700 ppm at the second point. The results of reducing CO levels using a banana peel air filter and zeolite were 66.6% at point 1 and 84% at point 2. The thing that caused the difference in measurement results at these two points was the different object placement of the equipment, at point 1 the measurement was carried out far from the CO source (vehicle) and at point 2 the measurement is carried out directly at the exhaust of the motor vehicle [13].
7.	Arduino Uno Based Air Filter as a Solution for Improving Air Quality in Class Sdn 003 Buildings in Tanjungpinang	The results of the research carried out are in the form of software design used for designing virtual prototypes. Next, use the Arduino microcontroller to make a simple prototype which will be used to find out if the function works correctly and get an evaluation from potential users. From the results of usability testing with potential users, it was found that the results of the innovation were good and easy to use in schools [2]
8.	Prototype of Cigarette Smoke Deodorizer in Smoking Rooms Equipped with Internet of Things	The cigarette smoke decomposing device that was designed and tested successfully met the initial design and functioned well. The use of an electrostatic precipitator and MQ2 sensor was proven to be effective in reducing cigarette smoke concentration by up to 86.1%. This tool also managed to function well, with the indicator that cigarette smoke can be sucked in quite quickly in less than a minute [14].
9.	Implementation Of Lora And Nodemcu Esp8266 Technology In Early Warning System Tools For Air Quality Monitoring	The reading results of these sensors are forwarded by the sensor node to the gateway to be displayed on a 0.96" OLED. The gateway is also equipped with a buzzer that will sound if a temperature reading value exceeds 40 oC is found, humidity does not meet the 45-65% RH range, and CO levels exceed 12 ppm. The test results showed that the buzzer function can work properly according to the specified sensor reading value and the maximum distance between the sensor node and the gateway for optimal data communication is a radius of 400 m when tested at the Politeknik Penerbangan Surabaya [15].
10.	Indoor Air Quality Classification and Monitoring using Thingspeak	This system has the potential to be used as an indoor air quality monitoring system to increase awareness about the importance of healthy air quality. In testing based on distance, the sensor produces good accuracy and is sensitive for detecting air conditions, then for performance testing thingspeak has good performance and provides direct visualization and can export data quickly when needed [16].

From some previous studies still discussing the problem of air pollution that occurs. Some previous studies have also innovations in the presence of tools that are integrated with technology. But this is still a number of things that need to be considered, such as costs, size, adjustment, and others for the general public. So from this study to complement the shortage of previous research, namely the presence of air filtering tools called Jl-RI 101. Jl-RI 101 is an air filtering tool that is still in the design stage to obtain designs in accordance with the current needs. great hope can solve a few problems that are happening lately.

2 Methods

This research was conducted through the approach of Research and Development (RnD) to find out the answers to the problem that was known. RnD is carried out to get the results of a particular tool design that is included with the effectiveness of the effectiveness of the air filtering device [17]. Then the following is the stages carried out in the development of this research, as in Figure 3. below.

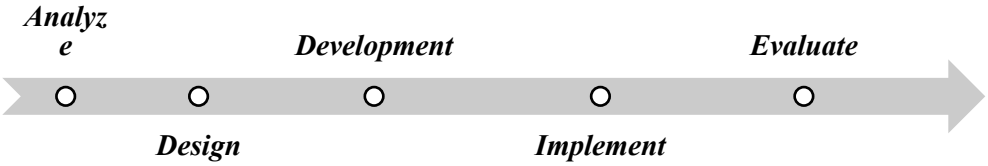

Fig. 3. Development with ADDIE Model

Through Figure 3. above is the stages of development to be carried out. The development of this study by using analyze, design, development, implement and evaluate (ADDIE) Model. Furthermore, each stage of the stages of the ADDIE Model is developed with the Internet of Things (IoT). This aims to explain every stages of the ADDIE Model. ADDIE Model has been considered very suitable for research that focuses on the development of instructional analysis and system design [18]. The following is the application of the ADDIE Model for the writing done.

1. Flow of analyze stages, Identification of Problems. This aims to determine the formulation of the problem, purpose and benefits of the results of the research that has been carried out. This study uses literature studies and field studies. The literature study is based on the results of theoretical studies, such as through journals, books, proceedings and several other scientific articles. Whereas in the field study based on the results of direct observations, interviews and filling in questionnaires with several respondents in previous studies.
2. Design stage flow, a tool design is designed from the results of the problem identification. Several stages carried out in the design of the tool, such as through a vacuum cleaner, washable pre filter, activated carbon deodorization filter, dust collecting filter, and Hardware Internet of Things. This aims to design a systematic tool and adjust to the needs of users of the air filtering device.
3. Development stages, the development of the design of the tool design was carried out. At this stage it focuses on developing the appearance of the Internet of Things (IoT) system that will be used. In addition, it is included by making concepts to support the tools well received. This aims to develop the application in the next stage.

4. Implement stage flow, the application of the results of the development is carried out. At this stage it focuses on applying the system that has been made from the results of previous development. In addition, with the illustration of the use of these tools, such as at home, shops, and others. This aims to make users better understand the addition of illustrations of the use of these tools.
5. The evaluation stages, testing tools from the results of the application. At this stage it focuses on testing the tools from the design results that have been carried out. Tool testing is carried out in a literature study of the results of previous writing/research similar to the current research. This is because the design of the tool with the Addie Model approach has been widely carried out, but what distinguishes from the function of the system

In addition, the current study is the development part of the research that has been done previously. Several previous studies entitled [19]: (1) "Design of absorbent tubes and gas emission cleaning" carried out by Idzani Muttaqin and Muhammad Suprapto, (2) "Design and IoT-Based Device for Neutralizing Cigarette Smoke Levels in a Room" was carried out by, (3) "Design Optimization of Portable Hepafis Plasma Air Purifier" is carried out by, (4) "Design and Build A Microcontroller -Based Automatic Ventilation Cover and Air Cleaner Control System Prototype" is carried out by, (5) "Internet of Things -Based Indoor Air Quality Monitoring System Design "is carried out by, (6)" Capability of Air Filtering Devices with Banana Mid and Zeolite Media to Reduce Carbon Monoxide (CO) Levels in the Air "is carried out by, (7)" Arduino Uno Based Air Filter as a Solution for Improving Air Quality in Class SDN 003 Buildings in Tanjungpinang "was carried out by, (8)" Prototype of Ciragette Smoke Deodorizer in Smoking Room Equipped with Internet of Things "was carried out by, (9)" Implementation of Lora and Nodemcu Tools for Air Quality Monitoring "is carried out by, and (10)" Indoor Air Quality Classification and Monitoring Using Thingspeak "is carried out by. Some previous studies similar to current research are follow -up development that adjusts to the current situation and conditions [20, 21]. So that the current research results are based on the references that have been tested, and the results will be in accordance with as they should.

3 Results and discussion

3.1 Analyze

This section focuses on the search and collection of information that has been done through literature studies. At this stage the search and collection of information about air pollution. In the search results and gathering of information as a form of adjustment with the functions and objectives of the Jl-RI 101. This aims to adjust the functions and objectives of Jl-RI 101 in daily life and as they should. The source and health standard for exhaust emissions in Table 2. below.

Table 2. Source and Health Standard for Exhaust Emissions

Pollutants	Source	Information
Carbon Monoxide (CO)	Waste of motor vehicles, some industrial processes	Health standards: 10 mg/m3 (9 ppm)
Sulfur Dioxide (SO2)	Heat and power plants	Health standards: 80 ug/m3 (0.03 ppm)

Pollutants	Source	Information
Exhaust Matter Particulates	Motorized vehicles, several industrial processes	Health standards: 50 ug/m3 for 1 year, 150 ug/m3
Nitrogen Dioxide (NO2)	Waste of Motorized Vehicles, Hot and Facilities	Health standards: 100 pg/m3 (0.05 ppm) for 1 hour
Ozone (O3)	Formed in the atmosphere	Health standards atmosphere: 235 ug/m3 (0.12 ppm) for 1 hour

The explanation in Table 2. above is a classification of the source and health standard of exhaust emissions. In each explanation of the table consists of pollutants, sources, and information about the specified health standards. This aims to find out air pollution is caused by anything, and where the source starts. While the effect of the Standard Air Pollutant Index (ISPU) in Table 3. below.

Table 3. Source and Health Standard for Exhaust Emissions

Category	Range	Carbon Monoxide (CO)	Nitrogen (NO2)	Ozone (O3)	Sulfur Dioxide (SO2)
Good	0-50	There is no effect	A little smelly	Wounds in several plant species due to combination with SO2 (for 4 hours)	Wounds in several plant species due to combination with O3 (for 4 hours)
Currently	51-100	Blood chemical changes but not detected	Smells	Wounds in several plant species	Wounds in several plant species
Not Healthy	101-200	An increase in cardiovascular in smokers who have heart disease	Smell and loss of color. Increasing the creativity of throat vessels in people with asthma	Decreased ability to athletes who practice hard	Smell, increased plant damage
Very Unhealthy	201-300	Increased cardiovascular in non -smokers who have heart disease, will appear some weaknesses seen in a real way	Increased sensitivity of patients with asthma and bronchitis	Mild exercise results in the influence of breathing in patients with chronic lungs	Increased sensitivity in asthma and bronchitis patients
Dangerous	>300	A dangerous level for all exposed populations			

The explanation in Table 3. above is a classification of categories based on the effect of air pollutant standard index. In each explanation of the table there is the explanation section regarding the range that is divided into five parts based on that category. Furthermore, consisting of carbon monoxide (CO), nitrogen (NO2), ozone (O3), and sulfur dioxide (SO2). In this case each explains the effect of the components of these chemical compounds.

3.2 Design

Design is a stage in the design of the tools of the predetermined problem, focusing on making the design of the tools and components contained in the tools made. Following Figure 4. is a tool that has been designed and made using Skethup 2022 design software.

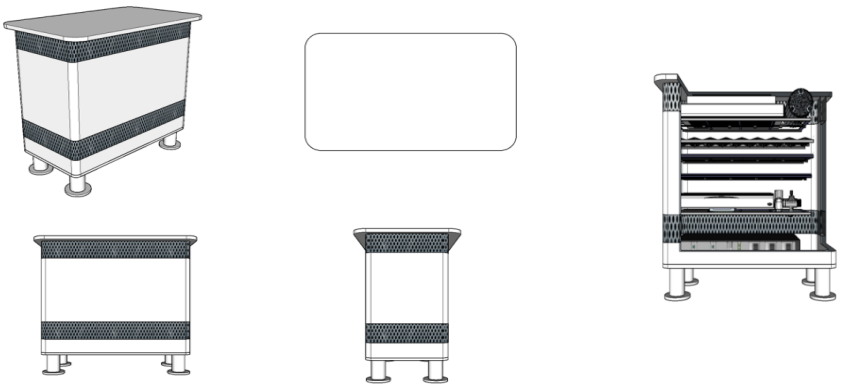

Fig. 4. Design JL-RI 101 with Sketchup 2022

In Figure 4. There are several components contained in the device named RL-RI 010 as follows: 1) This fan functions as a dirty air puller entering the tool, 2) The out fan functions as a clean air spreader from the air that has been through the system filter, 3) filter 1 or washable pre filter functions as the first filter that is useful for filtering dirty air containing large dust 4) Filter 2 or Actived Carbon Deodorization Filter functions as an odor removal filter from activated carbon carbon in the air, 5) Filter 5 or Dus Collecting Filter functions as a small dust dust collector as well as a killer of germs in the air that enters, 6) Hardware functions as a data warehouse considered by sensors and application use, 7) Compressor and Expansion valve function as a tool in running the fan . The components contained in the core tool functions as a filter for dirty air in the surrounding environment and the output releases clean air that is safe inhaled by living things. The following is a simulation of the use of RL-RI 010 contained in Figure 5.

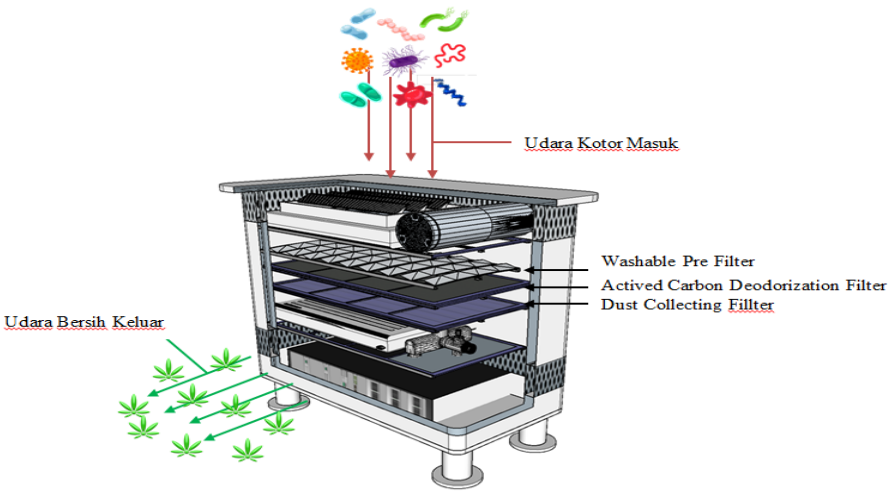

Fig. 5. Simulation JL-RI 101 with Sketchup 2022

3.3 Development

This section focuses on the development that is being carried out by Jl-RI 101. At this stage the development of simple applications given the name of the JL-RI 101 application. The design is still at the adjustment stage with the air filter which is integrated by the Internet of Things (IoT). This aims to facilitate its users in knowing, controlling, facilitating, and adjusting from the Jl-RI 101. At this time it still has a simple menu as a form of development prefix, namely Welcome, Home, Schedule, and Custom. Each of these menus has features and sub-fitur that adjusts to the needs of its users. But this is still necessary in the research and development stage to produce applications that are in accordance with the next user friendly concept. The following is an explanation of several menus in the JL-RI 101 application, as follows.

1. Welcome menu is a menu available for users in registering first. It aims to have an account, which consists of username and password. After having an account, the user can access the JL-RI 101 application to be able to control the air filter. So from this to make it easier for users to know the situation and conditions regarding the air from the JL-RI 101 application.
2. Home menu is the main menu that can be accessed, if the user already has an account and is registered in the JL-RI 101 application. This aims to determine the condition of the air filter that can be controlled by the application. In this home menu has several features such as: device name, temperature, air quality indicator, on and off buttons, fans, and adjusting the strength of the fan. So from this to make it easier for users to control the air filter from the JL-RI 101 application.
3. Schedule menu is one part of the main menu, including in the feature section called Device Name. This aims to scheduling on the date and/or what time the air filter tool works (effective when the air is dirty when on a certain day or month in accordance with the air quality information from the JL-RI 101 application). In this schedule menu has several sub-fitur sections such as: time/hour, date, and status on and off available. So from this to make it easier for users to manage air filters from the JL-RI 101 application.
4. The custom menu is one part of the main mernu, included in the feature section called the fan's strength adjustment. This aims to arrange the strength of the fan (effectively used when it is strong when the air is very dirty and used when it is slow when the air is clean enough). In this custom menu has several parts of information such as: regulating wind strength per day, air quality that is tailored to the power of wind, fan care if it is dirty, and other information. So from this to make it easier for users to adjust the air filter device from the JL-RI 101 application.

From each menu that is divided again in features, sub-fitur, and other information that has their own functions. So here are some functions of: Welcome menu serves to find out the situation and condition of the air, the home menu serves to control the air filter, the schedule menu serves to facilitate the user in adjusting the air filter, and the custom menu functions to adjust the air filter. From each of these that can be controlled in one application, which is given the name of the JL-RI 101 application. Giving the name is the same as the administration of the air filter, this has the aim that users can easily remember the name of the air filter. Attached in Figure 6. below.

Fig. 6. JL-RI 101 Applications

3.4 Implement

Implement, in this section focuses on the application that will be carried out by Jl-RI 101. At this stage the application of Jl-RI 101 as a form of illustration in daily life. In its application it is still at the adjusting stage by adjusting the shape and size of the air filter. This aims to adjust to the standard area of the average house in Indonesia. JL-RI 101 is an air filter that can be stored outdoors, such as on the roof of the house. It is intended that the air around the house becomes cleaner, healthier, and safe to be inhaled by living things. Because there are 5 categories of Air Force Standard Index (ISPU), namely: (1) Good category (1-50), (2) Medium category (51-100), (3) Unhealthy category (101-200), (4) Very unhealthy categories (201-300), and (5) dangerous categories (> 300). Each of these categories is divided to find out clean, healthy, and safe air or not to be inhaled by living things. JL-RI 101 has a very broad suction power, so it can adjust to the average standard area of the house in Indonesia. In this case further design will be carried out in order to get clean air needs that are in accordance with the average standard of the house in Indonesia. Then the following is the result of designing illustrations using Skecth Up software version 2022.

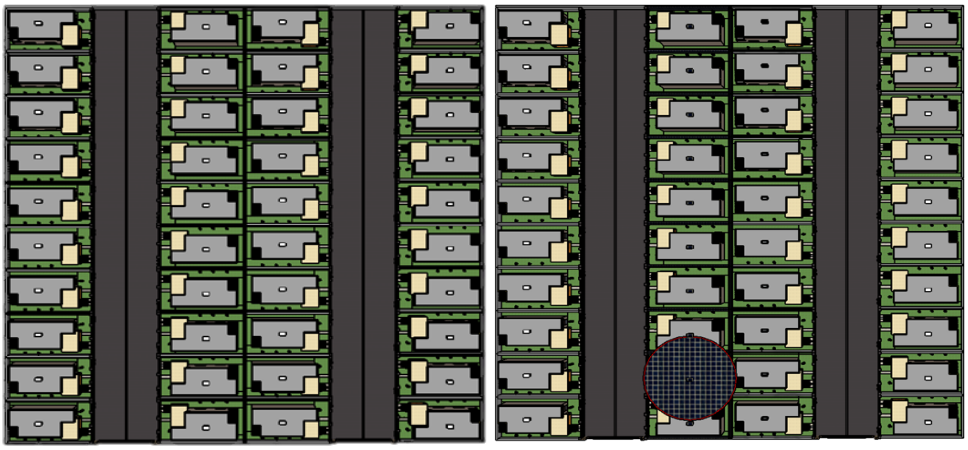

Fig. 7. Illustrations JL-RI 101 with Sketchup 2022

From Figure 7. above provides an illustration of the use of the air filter. It needs to be a note that the air filter device does not only apply to housing. But it can also be applied in shops, industry, or even places that are felt to produce significant dirty air pollution. It is intended that dirty air becomes clean air and is worthy of living in living things. JL-RI 101 is the name of the air filter that has a function to do air filtering. Especially some cases or phenomena that are currently happening in several major cities, such as: South Tangerang, Serang, Terpan, Tangerang City, DKI Jakarta, and others. The hope of the presence of the air filter can overcome a few problems that are ongoing. Through Figure 9. above is an illustration in the form of 3-dimensional (3-D), this is to illustrate that the tool can be applied in housing areas. Besides that gives an overview in terms of size for placement on the roof of the house. JL-RI 101 is an air filter that is integrated with the Internet of Things (IoT). This is to make it easier for users to know, control, facilitate, and adjust from the Jl-RI 101. Meanwhile through Figure 8. Below gave an additional illustration of its use.

Fig. 8. Additional Illustrations JL-RI 101 with Sketchup 2022

3.5 Evaluate

The evaluation stage is a stage that focuses on testing the tools from the application that has been done. This stage includes the performance and reliability of the tool by testing it in certain circumstances so as to get the various data needed. The data reads starting from the range of use of the tools and the amount of electricity needed to operate the tool. In the case of design a simulation of the range contained in the Figure 9. below this.

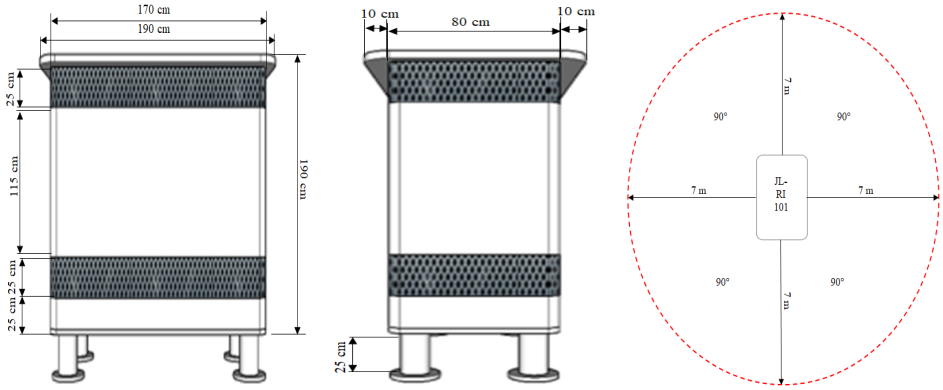

Fig. 9. Evaluate JL-RI 101 with Sketchup 2022

Can be seen in the picture above when the tool is used in range that can be used quite large in a housing scale simulation which certainly makes the air in the home environment clean and healthy.

4 Conclusion

Lately there are several innovations as a solution in overcoming air quality problems in several major cities. One of them is the application of Beyond Fresh taken from the latest generation of aircraft technology, related to indoor aerodynamics. But this is still in the current research and development stage to get optimal results. Motorcycle or car vehicles and industry as part of the main contributor to the cause of air pollution in several major cities. In addition, in some major Koita as an economic and business center that has a dense traffic level. So this results in exhaust emissions and harmful particles. The Industry Sector which continues to grow rapidly as well as one of the preparations for air pollution. In this case the community and other stakeholders are the hope of participating in minimizing air pollution that harms health and the environment. Through some collective actions that have been carried out, it might minimize the ongoing air pollution problem. In this case JL-RI 101 is present as a form of one of the efforts to reduce city air pollution and be replaced with clean air. So that through this application can adjust to the needs of its users later, which is given an illustration in Figure 7. and 8. above. In addition, the following is the result of strength, weaknesses, opportunities, and treats (SWOT) analysis which is carried out on the air filter. As in Table 4. below.

Table 4. Strength, Weaknesses, Opportunities, and Treats (SWOT) Analysis

Strength	
1.	The first tool as an air filter used outdoors.
2.	Tools that can be connected with IoT through the application created.
3.	Tools that can be used in any field of building.
4.	Tools resistant to rain.
5.	Tools with futuristic shape.
Weaknesses	
1.	The limited distance of the spread of the clean air issued.
2.	The limited features that exist in the use of the application.
3.	There are still adjustments to different building.
4.	There are still differences if used in different building concepts.
5.	There is still a possibility of rust if not maintained maintenance.
Opportunities	
1.	Design of tools in accordance with the current needs with the amount of polluted air.
2.	The development of technology is increasingly used at this time.
3.	Clean air needs in the industrial and family sectors.
4.	Design of the tool is very suitable for the concept of modern buildings that are widely used today.
5.	Tools can survive uncertain season changes.
Treat	
1.	The occurrence of distrust of the design of newly made tools.
2.	There is the development of other applications beyond the applications created.
3.	Users' unwillingness to additional costs in purchasing tools.

4. Differences in user to the desired design concept.
5. High acids from rainwater.

References

[1] M. F. B, F. D. Lestary, A. Hidayat, D. Fadhilatunisa and A. Eka, "Prototype Sistem Monitoring Pendeteksi dan Penyaringan Udara pada Ruangan Berbasis Internet of Things (IoT)," *Jurnal MediaTIK: Jurnal Media Pendidikan Teknik Informatika dan Komputer,* pp. 1-8, 2023.

[2] D. Nursyirwan, "Penyaring Udara Berbasiskan Arduino Uno Sebagai Solusi Untuk Memperbaiki Kualitas Udara Di Dalam Ruangan Kelas Sdn 003 Binaan Tanjungpinang," *Jurnal Teknik,* vol. 9, no. 1, pp. 1-9, 2020.

[3] S. Fedora and P. E. Ariaji, "Analisis Kebutuhan Penyaringan Udara untuk Mengatasi Polusi Udara sebagai Strategi Akupuntur Kota di Kawasan Industri Pulogadung," *Jurnal Stupa : Sians, Teknologi, Urban, Perancangan, Arsitektur,* pp. 2717-2728, 2022.

[4] E. Kurniawan and F. D. Suprianto, "Penelitian Filter Udara Mobil Menggunakan Sabut Kelapa Kering sebagai Pengganti Bahan Filter Udara Aftermaarket," *Jurnal Mechanova,* pp. 1-7, 2016.

[5] M. N. Hasani, N. Halimah and Ernawati, "Alat Penyaring Asap Sederhana," *SPEKTRA: Jurnal Kajian Pendidikan Sains,* pp. 150-161, 2020.

[6] Mutamirah and B. Sunu, "Kemampuan Alat Penyaring Udara dengan Media Pelepah Pisang dan Zeolite untuk Menurunkan Monoksida (CO) di Udara," *Jurnal SULOLIPU,* vol. 19, no. 1, pp. 137-142, 2019.

[7] F. Mudhofir, I. Yulianti and S. Sujarwata, "T-FANTYQ 09: Teknologi Lingkungan Penyaring Udara sebagai Upaya Degradasi Polutan Asap Rokok," *Jurnal MIPA,* pp. 1-5, 2018.

[8] I. Muttaqin and M. Suprapto, "Perancangan Tabung Penyerap dan Pembersih Gas Emisi," *Jurnal EEICT,* vol. II, no. 1, pp. 1-8, 2019.

[9] F. Surahman, M. kamal and Azhar, "Rancangan Bangun Alat Penetlarisir Kadar Asap Rokok dalam ruangan," *Jurnal TEKTRO,* vol. VI, no. 6, pp. 11-16, 2022.

[10] D. Sugianto, Hidayatullah and A. S. Uyun, "Optimasi Desain Portable Hepafis Plasma Penjernih Udara Menggunakan Sinar UVC untuk Mengurangi Polutan dalam Ruangan," *Jurnal ROTASI,* vol. 24, no. 1, pp. 19-29, 2022.

[11] M. I. Tiara and N. Firmawati, "Rancang Bangun Prototipe Sistem Kontrol Penutup Ventilasi dan Pembersih Udara Otomatis Berbasis Mikrokontroler," *Jurnal Fisika Unad,* vol. 12, no. 3, pp. 1-9, 2023.

[12] G. Rumampuk, V. Porkorl and A. rumangit, "Internet of Things-Based Indoor Air Quality Monitoring System Design," *Jutnal Teknik Informatika,* vol. 17, no. 1, pp. 11-18, 2021.

[13] Mutamirah and B. Sunu, "Kemampuan Alat Penyaring Udara dengan Media Pelepah Pisang dan Zeolite untuk Menurunkan Monoksida (CO) di Udara," *Jurnal SULOLIPU,* vol. 19, no. 1, pp. 137-142, 2019.

[14] G. P. Utomo, E. Kurniawan and R. I. Vidyastari, "Prototype Alat Pengurai Asap Rokok Pada Smooking Room Dilengkapi Internet of Thing," *Digital Tranformation Technology,* vol. 3, no. 1, pp. 11-17, 2023.

[15] F. Faizah, K. Kustori, I. W. Wiguna, S. Suhanto and A. Abdullah, "IMPLEMENTASI TEKNOLOGI LORA DAN NODEMCU ESP8266 PADA ALAT EARLY WARNING SYSTEM UNTUK PEMANTAUAN KUALITAS UDARA," *Juernal Penelitian,* vol. 8, no. 1, pp. 42-55, 2023.

[16] A. D. Ramadhani, N. Ningsih, A. Nurcahya and N. Azizah, "Klasifikasi dan Monitoring Kualitas Udara Dalam Ruangan menggunakan Thingspeak," *Jurnal Teknik Elektro dan Komputer,* vol. 10, no. 1, pp. 1-8, 2023.

[17] I. Salamah, R. Tapera and I. Hadi, "Alat Penjernih Udara dengan Sensor Radar RCWL dan Monitoring PM2.5 Berbasis Iot," *JTEV (Jurnal Teknik Elektro dan Vokasional),* pp. 349-359, 2022.

[18] S. Sentiyaki, A. R. A. Astuti, I. Fathurrahman, S. Yani, M. Mandasini, N. Nurjannah and Z. Sabara, "Alat Penyaring Karbon Monoksida pada Knalpot Kendaraan Bermotor dengan Menggunakan Adsorben Alami Ekstrak Daun Trembesi," *Journal of Chemical Process Engineering,* pp. 38-42, 2018.

[19] P. Sidebang, A. Safitri, A. S. Rahdatia Magvira S. Tarafannur, N. K. Mafud and G. M. Lahe, "Sistem Filtering Berbahan Daun Mangga untuk Emisi Partikulat Matter," *Jurnal Kesehatan Masyarakat Jambi (JKMK),* pp. 23-31, 2022.

[20] A. A. S. Ramschie, J. F. Makal and V. V. Ponggawa, "Sistem Pendeteksi dan Penginformasi Kekotoran Penyaring Udara pada Penghematan Listrik," *8th Industrial Research Workshop and National Seminar,* pp. 647-652, 2017.

[21] D. Nusyirwan and A. Fikri, "Penyaring Udara Berbasiskan Arduino Uno sebagai Solusi untuk Memperbaiki Kualitas Udara di dalam Ruangan Kelas SDN 003 Binaan Tanjungpinang," *Jurnal Teknik : Universitas Muhammadiyah Tangerang,* pp. 53-62, 2020.