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Performance Analysis Air Quality Monitoring Based on Arduino with Web Server

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***Abstract*—** *Air quality is one of the main factors that determine health. Therefore, the human need for clean air is something that cannot be underestimated. Air quality varies. This is because the number of sources of air pollutants in each place is different. Air pollution is a simple thing but very dangerous if allowed to continue. The lack of attention from the public towards the parameters of the surrounding air pollutants in the midst of developing technology is very unfortunate. Therefore we need a monitoring tool to monitor air pollutant gases and the results can be monitored in Real-Time. In this study, designed a tool that can monitor the parameters of Web Server-based air pollutants. Data displayed through web pages. On the web page, the data shown is the value of the temperature and humidity sensor, CO (Carbon Monoxide) sensor, CO2 (Carbon Dioxide) sensor, and O3 (ozone) sensor. Some gas parameters have normal, moderate and high thresholds. The average threshold value for normal is 0 to 35 ppm, and the highest is 100-200 ppm. From the data generated sensor readings, obtained an error of 3% on CO2 sensors, 2% for O3 sensor readings, and 4% for CO sensors. The value of the sensor can later be viewed based on the time of data retrieval using a table or graphical display..*

***Keywords*—** *Real-Time, Web Server, sensor, ESP 8266 12E, Air Quality.*

I. INTRODUCTION

Human needs for clean air become an important thing. Without clean air, there will be many long-term diseases that can attack humans. Such as Carbon Monoxide (CO) pollutants produced by combustion of motor vehicle fuel. If humans continue to inhale it, the respiratory system will be disrupted. Therefore, it can be said that air quality is one of the main factors affecting human health. In Indonesia, there is an ISPU (Air Pollution Standards Index) issued based on the Decree of the Minister of Environment Number: KEP 45 / MENLH / 1997 as a reference for determining air quality. In ISPU, 5 parameters of air pollution are used. Namely Carbon Monoxide (CO), Sulfur Dioxide (SO2), Nitrogen Dioxide (NO2), Ozone (O3), and Particulates (PM10).

For existing research, there are several systems created to monitor air quality. According to Yulfiani Fikri, et al. (2013), in a study entitled "ATMega 8535 Microcontroller-Based Air Quality Monitoring System with TCP / IP Communication Protocol", has created a system that can monitor air quality by displaying NO2 and CO pollutant parameters. The system created uses the WIZ110SR module to send pollutant parameter data to the server and the data will then be displayed via a local web page. The disadvantage of the system being made is that the system is only connected to the local server using a UTP cable to see the value of the air pollutant parameters. Furthermore, research conducted by Kiki Azhari MOS., S., MCTNA et al. (2016), entitled "Design of Indoor Air Quality Monitoring Systems with TCP / Ip Communication Based on Atmega16 Microcontroller". The system created can detect NO2, CO2 and temperature parameters. Data that has been processed will be sent to the local server using the WIZ110SR module. Furthermore, data will be displayed via the LCD. The weakness of this system is that air pollutant information can only be seen through the LCD and can only be accessed locally.

To overcome the shortcomings of these tools, the idea emerged to make an "Performance Analysis Air Monitoring Based on Arduino with Web Server" which will later be used for monitoring air quality. This tool detects the level of air pollution, along with an analysis of air condition data from the detected level by health standards. The data obtained is viewed through the web and android and imported into the .xlsx format which can later be monitored in Real-Time with a web server. Through this tool, it is expected that problems regarding air quality can be identified and can be anticipated.

II. THEORY

A. Air Pollution Standards Index

The Air Pollution Standard Index or ISPU is a number that does not have a unit that describes the condition of air quality within a certain time period based on its impact on humans and other living things.

ISPU is used officially in Indonesia following the Decree of the State Minister for the Environment Number: KEP 45 / MENLH / 1997 Concerning Air Pollution Standards Index. The Air Pollution Standard Index is determined by changing the air pollutant content to a number that has no unit value.

R. Gaguk Pratama Yudha, Alfi Tranggono Agus Salim, Rakhmad Gusta Putra, and R. Oktav Yama Hendra, "Performance Analysis Air Monitoring Based on Arduino with Web Server," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 3, pp. 412-417, 2019.

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Table 1. Air Pollution Standard Index Range

Kategori	Rentang	Penjelasan
Good	0 – 50	The level of air quality has no effect on human or animal health and has no effect on building plants and aesthetics
Midle	51 – 100	The level of air quality that does not affect human or animal health but affects sensitive plants and aesthetic value.
Not healthy	101 – 199	The level of air quality is detrimental to humans or groups of animals that are sensitive or can cause damage to plants or aesthetic value.
Very unhealthy	200 – 299	The level of air quality that can be detrimental to health in a number of exposed population segments.
Danger	300 – lebih	Dangerous air quality levels that generally can seriously harm health.

In ISPU, there are 5 air pollutants which are used as parameters to determine the quality of air. These parameters are calculated and compared with the ISPU range to determine which parameter is of greater value. The five air pollutants include:

1. Partikulat (PM10)
2. Karbon Dioksida (CO)
3. Sulfur Dioksida (SO2)
4. Nitrogen Dioksida (NO2)
5. Ozon (O3)

as explained n ppm gas i =, where ntotal = 106 mol, and specifically at STP conditions (standard temperature and pressure, 0 C and 1 atm) 1 mole of any gas has a volume of 22.4 L so that at STP applies,

$$a\ ppm\ gas\ i = \frac{a(mol)gas\ i}{n_{total}\ udara(mol) \times 22{,}4(\frac{l}{mol})} = \frac{a}{10^6 \times 22{,}4}\left(\frac{mol}{L}\right) = \frac{a}{10^6 \times 22{,}4}M \quad ..(1)$$

note: if the condition is not STP, then the permol volume of any gas (Vi/ni) = RTi/Pi, or

$$\frac{V_i}{n_i}\left(\frac{L}{mol}\right) = 22{,}4\left(\frac{L}{mol}\right) \times \frac{Ti(K) \times 1(atm)}{273{,}13(K) \times Pi(atm)} \quad \text{.....(2)}$$

with R = 0,0821 L.atm/(mol.K), T on Kelvin, and P on atm.

B. Design System

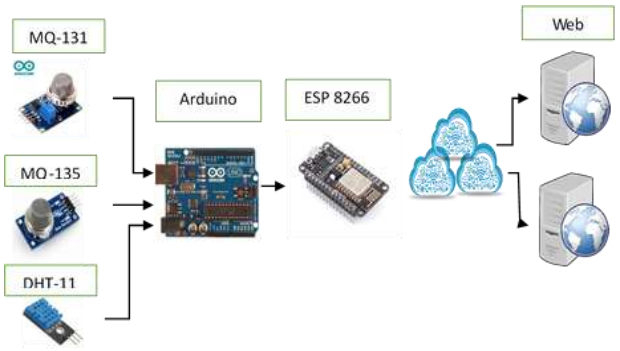

Figure 1. Air Monitoring Diagram System

In the Arduino-based Air Monitoring Performance Analysis Analysis with Web Server, we designed an air monitoring system in real-time and can be monitored through a web server. The explanation in Figure 1, the monitoring tool sends data to the monitoring system using an internet connection. Inside the device, there are several components, namely temperature sensors, CO, CO2 and O3 and air humidity that serves to detect temperature and humidity in the air, air pollutants CO, CO2, and O3.

Arduino UNO which functions as a place to process data obtained from each sensor. Data will be given a value based on the reading from the sensor. Data will then be sent to the transmitter. ESP8266 12E which functions to send data that has been processed by Arduino UNO to a database that is connected to a web server. In this ESP8266 12E, fill in the address of the database that is connected to the web server.

The data sent is then received in the monitoring system section. in the monitoring system section, there are several parts, a web server that functions to hold files that are used to display web pages. Web server also functions to direct data from ESP8266 12E to the database.

Database that functions to store the sensor readings processed by Arduino UNO. A web page that functions to monitor air quality in real-time by taking air pollutant parameter data from the database through the web server.

C. Monitoring Work System

In the monitoring system section, there is a system that regulates incoming and outgoing data so that it can be viewed through a web page. The working diagram of the monitoring system can be seen in the Figure below.

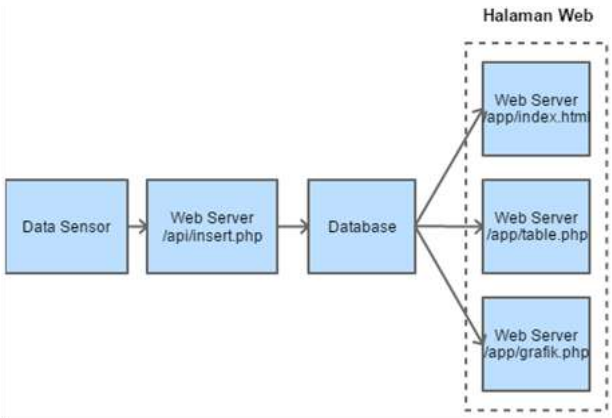

Figure 2. Block Diagram of Monitoring System

Data from the sensor will be sent to the web server with the address /api/insert.php. that is, the data will enter the insert.php program in the folder named API on the web server. The insert.php program functions to send data to the database. From the database, data will be grouped and stored according to the corresponding parameter name fields. Data in the database will then be displayed on the web page. Web pages on the monitoring system that are made are divided into 3 namely index.html to display the homepage, table.php to display sensor data in tabular form, and graph.php to display sensor data in the form of a graph display.

On the web pages of the system created, there are 3 ways to display data from the sensor. Namely, by accessing the homepage display, tables, and graphics.

R. Gaguk Pratama Yudha, Alfi Tranggono Agus Salim, Rakhmad Gusta Putra, and R. Oktav Yama Hendra, "Performance Analysis Air Monitoring Based on Arduino with Web Server," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 3, pp. 412-417, 2019.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

research.student.pnm.ac.id/airmonitoringpnm/index.html is a link to access the home page. The home menu displays page of the final project "Web Server Based Air Quality Monitoring System" along with the information can be seen in Figure 3.

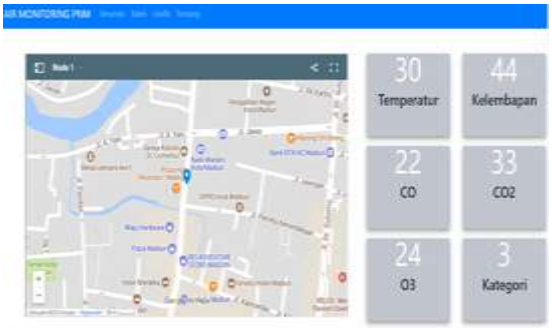

Figure 3. Homepage display menu with description

D. Sensor DHT 11 dan ESP 8266 12E

DHT11 is a multi-sensor module for temperature and relative humidity that produces a calibrated digital output. This sensor is reliable and stable, in the form of a capacitive polymer that senses elements for temperature and relative humidity sensors. Figure 4 is a block diagram of DHT11.

Figure 4. Sensor DHT11

DHT11 is a multi-sensor module for temperature and relative humidity node MCU is an IoT platform that is open source. Consists of hardware in the form of System On Chip ESP8266 from ESP8266 made by Expressive System, as well as the firmware used, which uses the Lua scripting programming language. The term NodeMCU by default refers to the firmware used rather than the hardware development kit. hat produces a calibrated digital output. This sensor is reliable and stable, in the form of a capacitive polymer that senses elements for temperature and relative humidity sensors. Figure 4 is a block diagram of DHT11.

NodeMCU can be analogous to the ESP8266 Arduino board. In the ESP8266 tutorial series embeddedness once discussed how to program ESP8266 is a bit troublesome because it requires some wiring techniques and an additional USB to serial module to download the program. However, NodeMCU has ESP8266 package into a compact board with various features like a microcontroller + access capability to Wifi as well as a USB to serial communication chip. So to program it only requires a USB data cable extension that is used as a data cable and Android smartphone charging cable.

Figure 5. ESP 8266 12-e

E. Sensor MQ-131 dan MQ-135

The O3 MQ-131 gas sensor works in the same way as the MQ-7 and MQ-135 sensors but the air quality variable measured is different. MQ-131 sensor serves as an input to determine the level or concentration of O3 gas in the room being monitored.

This sensor has 6 pins, 4 pins are used to pick up the signal, and 2 others are used to input the sensor supply. The MQ-131 gas sensor has a high sensitivity to Ozone. When using this sensor, sensitivity adjustment is very necessary. It is recommended to calibrate the sensor at 50 ppb O3 in the air and use a load resistance (RL) value of around 100 KΩ. For measurement accuracy, the measurement point for the gas sensor must be precisely determi

Figure 6. MQ-131

MQ-135 is a sensor that provides air quality information. This sensor informs the results of air quality detection in the form of changes in the analog resistance value at the output pin. The output pin can be connected to the ADC (Analog-to-digital-converter) pin on the microcontroller. The MQ-135 sensor has a high sensitivity to ammonia, sulfide, smoke and harmful gases. Based on the datasheet, this sensor requires a voltage of 5V. Figure 6 is a physical form of MQ-135.

Figure 7. MQ-135

The sensor sensitivity adjustment is determined by the different resistance values of MQ-135 for various gas concentrations. So, when using this component, sensitivity adjustment is very necessary. Also, a gas detection calibration is also needed.

III. TESTING AND ANALYSIS

The testing phase is carried out on "Web-Based Air Quality Monitoring Design". With this test, we can obtain data that can be analyzed to determine the feasibility of the tool that has been made.

A. Testing MQ-7, MQ-135, and O3

The results of the MQ-7 test are MQ-7 can detect CO gas. The following table shows the results of the data that has been analyzed through several tests conducted with a comparison of paper burning smoke.

Table 2. Test Results With Paper Burning Smoke

No	CO gas results without smoke	CO gas results with smoke
1	4	19
2	4	22
3	4	20
4	4	26
5	4	21

R. Gaguk Pratama Yudha, Alfi Tranggono Agus Salim, Rakhmad Gusta Putra, and R. Oktav Yama Hendra, "Performance Analysis Air Monitoring Based on Arduino with Web Server," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 3, pp. 412-417, 2019.

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According to the above test results, it is known that MQ-7 can display gas output on the Arduino uno microcontroller board. Data between CO without smoke with CO data with paper burning smoke is very different. But the results of CO gas with combustion fumes are not stable due to air and wind factors around the test. So it can be concluded that MQ-7 can work well and produces an average error reading of 2%.

The results of the MQ-135 test are MQ-135 can detect CO2 gas. The following table shows the results of the data that has been analyzed through several tests conducted with a comparison of paper burning smoke.

Table 3. Test Results With Paper Burning Smoke

No	CO gas results without smoke	CO gas results with smoke
1	12	23
2	12	24
3	12	24
4	12	23
5	12	23

According to the test results above, it is known that the MQ-135 can display gas output on the Arduino UNO microcontroller board. The data between smokeless CO2 and CO2 data with paper burning smoke is very different. But the results of CO2 gas with combustible smoke are not stable due to air and wind factors around the trial. So it can be concluded that the MQ-135 can work well and produces an average error reading of 4%.

Furthermore, O3 sensor testing, the results of the MQ-131 test are MQ-131 can detect O3 gas. The following table shows the results of the data that has been analyzed through several tests conducted with a comparison of paper burning smoke.

Table 4. Results of O3 Gas Readings in Ppb

No	O3 gas reading results in ppb
1	6
2	6
3	7
4	6
5	6

According to the above test results, it is known that MQ-131 can display gas output on the Arduino UNO microcontroller board. So it can be concluded that MQ-131 can work well and has an average error of 3%.

B. *Testing Data Transmitter ESP 8266 12E to Database*

The test aims to determine whether each sensor can send parameter values to the fields in the database with the appropriate name. This test is done by entering data manually according to the syntax in the Web Browser. The test is carried out with the value entered based on the data input syntax. The data transmission test table is found in table 5.

Table 5. Table Testing Data Transmitter

Value entered					
temp	hum	co	co2	o3	category
1	1	1	1	1	1

The results of the tests carried out can be seen in the table 5.

id	temp	hum	co	co2	o3	kategori	tanggal
237	1	1	1	1	1	1	2018-07-18 02:16:14
236	30.00	25.00	4	8	8	1	2018-07-17 14:26:29
234	33.00	25.00	4	8	7	1	2018-07-17 14:23:24
233	34.00	25.00	3	8	8	1	2018-07-17 14:22:47

Figure 8. Database Test Results

C. *Overall Testing*

Data entered in this test will fit within the ISPU range. Data to be entered in the CO, CO2, O3, and category sensors in the database can be seen in Table 6.

Table 6. Testing Data for CO, CO2, and O3 Sensor Values

Field Database	Values in the ISPU range				
CO	50	100	199	299	300
CO_2	50	100	199	299	300
O_3	50	100	199	299	300
Category	1	2	3	4	5

The display in the database field after entering data will look like Figure 9. It is known that the data entering the fields in the database is in accordance with the test data in table 6.

id	temp	hum	co	co2	o3	kategori	tanggal
392	27.00	42.00	300	300	300	5	2018-08-06 08:51:17
391	27.00	42.00	299	299	299	4	2018-08-06 08:51:00
390	27.00	42.00	199	199	199	3	2018-08-06 08:50:47
389	27.00	42.00	100	100	100	2	2018-08-06 08:50:29
388	27.00	42.00	50	50	50	1	2018-08-06 08:50:05

Figure 9. display on the database.

Figure 10. Parameter Value Categorization Testing Results

From the test results found that the numbers contained in the fields in the database can be changed according to the test data table. If the sensor value is in the range 1-50 and the number in the category field is 1, the background color displayed is green and the category bar displays "healthy". If the sensor value is in the range 51-100 and the number in the category field is 2, the background color displayed is blue and

R. Gaguk Pratama Yudha, Alfi Tranggono Agus Salim, Rakhmad Gusta Putra, and R. Oktav Yama Hendra, "Performance Analysis Air Monitoring Based on Arduino with Web Server," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 3, pp. 412-417, 2019.

International Research Journal of Advanced Engineering and Science
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the category bar displays "medium". If the sensor value is in the range 101-199 and the number in the category field is 3, the background color displayed is yellow and the category bar displays "unhealthy". If the sensor value is in the range 200-299 and the number in the category field is 4, then the background color displayed is red and the category bar shows "very unhealthy". And finally, if the sensor value is in the range of more than 300 and the number in the category field is 5, the background color displayed is gray and the category bar displays "dangerous". Data detected by the sensor is still in the form of ppm value data. In the tool section, the data is then converted to ISPU numbers contained in the ISPU range.

In this test, 3 categories used in ISPU are healthy, moderate and unhealthy. Provisions for calculating ppm values based on ISPU are:

1. he range of 0 - 50 with a ppm value range of 0 ppm - 33 ppm will be categorized as "healthy".
2. Range 51 - 100 with ppm value range 34 ppm - 59 ppm will be categorized as "medium".
3. Range 101-199 with ppm values above 60 ppm will be categorized as "unhealthy".

When testing takes place, data is taken according to these 3 categories. In the healthy category, the data entered can be seen in Graph 1.

Graph 1. Healthy Category Testing Data

From Graph 1, it was found that CO, CO2, and O3 values had values below 33 ppm which detected air quality was "healthy" according to the test. Next is Graph 2, which shows the medium category testing data.

Graph 2. Medium Category Testing Data

From Graph 2, it was found that the CO2 values on the 5th and 6th picks had values above 34 ppm which were 36 ppm each, which detected air quality at the time of testing was "medium". Next is Graph 3 which displays the testing data for the "unhealthy" category.

Graph 3. Unhealthy Category Testing Data

From Graph 3, it was found that CO values on the 8th up to 11th take have values above 60 ppm which is 63 ppm. Which is, the air quality that was detected at the time of the test was "unhealthy".

IV. CONCLUSION

Based on the system test results obtained on " Performance Analysis Air Monitoring Based on Arduino with Web Server " it can be concluded that:

a) In the table display, the monitoring system can categorize "healthy" air quality if the value is in the range 1-50, categorize "medium" if one of the values is in the range 51-100, categorize "unhealthy" if one of the values is within range 101 -199, categorizing "very unhealthy" if one value is in the range 200-299, and categorizing "dangerous" if one value is in the range of 300 and above
b) From the data generated sensor readings, an error of 3% was obtained on the CO2 sensor, 2% for the O3 sensor reading, and 4% for the CO sensor.
c) With the web server-based air quality monitoring tool able to provide information that is important to maintain health. With efforts to plant trees and add green open land, to reduce the impact of pollution.

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REFERENCES

[1] R. Gaguk Pratama Yudha And Dirvi Eko J., "Analysis of unsynchronization carrier frequency offset for OFDM system using moose estimation method" *International Research Journal of Advanced Engineering and Science* , Volume 2, Issue 4, pp. 42-45, 2017.
[2] R. Gaguk Pratama Yudha , I Gede Puja Astawa, Amang Sudarsono., "Performance Analysis of CP-Based and CAZAC Training Sequence-Based Synchronization in OFDM System" *EMITTER International Journal of Engineering Technology*, Vol. 4, No. 2, December 2016.
[3] Ghofar Noor Mahendro., Monitoring Kualitas Air Danau menggunakan Sensor Turbidity, pH, Suhu Berbasis Web. Tugas Akhir, Politeknik Negeri Madiun, 2016.

R. Gaguk Pratama Yudha, Alfi Tranggono Agus Salim, Rakhmad Gusta Putra, and R. Oktav Yama Hendra, "Performance Analysis Air Monitoring Based on Arduino with Web Server," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 3, pp. 412-417, 2019.

[4] Muhammad Rizqi Zulkarnain., "Sistem Monitoring Kualitas Air Sungai Yang Dilengkapi Dengan Data Logger Dan Komunikasi Wireless Sebagai Media Pengawasan Pencemaran Limbah Cair", Tugas Akhir, Institut Teknologi Sepuluh Nopember, 2015.
[5] Sulaiman. *Jenis-jenis Limbah.* Termuat dalam https://sulaimantap.wordpress.com/2011/03/04/jenis-jenis-limbah/, 2011.
[6] Rosani, Dwi. *Pengelolaan Limbah Cair untuk Pengendaian Pencemaran Air*. Termuat dalam http://dewienvironmental.blogspot.co.id/, 2010.
[7] Putra, Mandala. 2010. *Turbiditas (Kekeruhan).* Termuat dalam http://mandala-manik.blogspot.co.id/2010/01/turbiditas-kekeruhan.html.
[8] Yuliani Fikri, dkk., (2013). Sistem Monitoring Kualitas Udara Berbasis Mikrokontroller ATMega 8535 Dengan Komunikasi Protokol TCP/IP. Jurnal Fakultas Teknik Universitas Diponegoro, 2302-9927, 664.
[9] Adam Faroqi, dkk, (2017). Perancanga Alat Pendeteksi Kadar Polusi Udara Menggunakan Sensor Gas MQ-7 Dengan Teknologi Wireless HC-05. Teknik Elektro Fakultas Sains dan Teknologi.
[10] Kiki Azhari MOS., MCTNA dan H. Lukman Abdul Fatah M.Si, M.T. Perancangan Sistem Monitoring Kualitas Udara Dalam Ruangan Dengan Komunikasi Tcp/Ip Berbasis Mikrokontroler Atmega16. Jurnal Manajemen Informatika dan Teknik Informatika LPKIA.

R. Gaguk Pratama Yudha, Alfi Tranggono Agus Salim, Rakhmad Gusta Putra, and R. Oktav Yama Hendra, "Performance Analysis Air Monitoring Based on Arduino with Web Server," *International Research Journal of Advanced Engineering and Science*, Volume 4, Issue 3, pp. 412-417, 2019.