Air Quality Monitoring and Decision Support System Using IoT

A. A. Mashuri[1], and N.Zulfa.[2]
[1] STMIK HIMSYA Semarang, Central Java 50232, Indonesia
[2] IVET University, Semarang, Central Java 50235, Indenesia

Abstract— Air Pollution Standard Index in a city is Semarang City with PM 10 7 and Air Quality Index (AQI) 67. Air pollution monitoring with portable systems is rarely found to obtain direct data. This research aims to make a portable device to determine air quality in the city of Semarang to facilitate control. Air quality testing is integrated with Internet of Things technology to adjust the conditions of the 4.0 industrial revolution so that air conditions are immediately known in real-time. The prototype method is a series of systems that determine the air quality and quantity of components. The prototypes are the MQ-6 type sensor for CO2 and smoke identification, MQ-7 (CO, LPG, and CH4), MQ135 (Butane and Air Quality), and DHT-11 (Humidity and Temperature). Gas sensors equipped with an Arduino microcontroller were tested to produce an average condition of pollution in a traffic activity, namely 7.06 ppm and 4.77 ppm for CO and CO2, which have exceeded the threshold, while NH3 and C4H10 are 0.025 ppm and 0 ppm are still below threshold. This value indicates that the pollutants that affect, especially CO and CO2, result from the combustion of land transportation.
Index Terms— Air quality; sensors; IoT; Internet; Pollution;

1. Introduction

The main objective of the Air Quality Monitoring and Decision Support System in Semarang City Using this IoT is that air pollution is a problem that is currently very important to be overcome. This system is for monitoring air quality [1][2]; and keeping it under control for a healthier future and healthier life for all. The internet of things (IoT) is increasingly popular day by day because it can change lives and make it easier for humans. With the population growth and with the increase of cars and industry, the atmospheric conditions are deteriorating greatly by the day. The risky effects of the pollution include some allergic reactions that cause eye, nose and throat irritation. It can also cause inflammation within the lungs which opens the way to problems such as bronchitis, heart disease, pneumonia, worsening lung and asthma[3].

These pollution-related problems can be overcome by having an efficient monitoring system. Observations provide measurements of air pollutant concentrations, which can then be examined, interpreted and presented. Environmental monitoring with intelligent systems allows us to measure the extremities of air pollution which can be used to develop techniques to reduce it. IoT, when applied to industry, is broadly defined under the Industrial IoT (IIoT) category. Environmental responsibility and worker safety go hand in hand with increasing the efficiency and productivity of any industry. This research mainly focuses on monitoring pollution especially applicable to the city of Semarang. The city of Semarang, which is the administrative and industrial centre of Central Java, has recently increased its temperature to 38^0-40^0C. Some of them may be fatal to human life if inhaled more than ppm [4], [5]. Leaks such as Butane, Methane, CO_2, and, CO. Must be monitored to avoid explosions and accidents An effective monitoring system will help identify the air quality index level. This system can be built by implementing sensors that can detect various gases. Sensors will send data to Google cloud servers where users can monitor data wherever they are[3]. Notifications can be started to alert users who are in a certain area in the form of a colour indicator (red, yellow, green). Thus, precautions can be taken to reduce air pollution in an area.

Many types of research on air quality have been carried out by combining current technology that is connected to the internet which makes it easier to use to monitor it. The research was carried out using the MQ135 sensor which is the best choice for monitoring Air Quality because it can detect the most dangerous gases and can measure the amount accurately. We can monitor pollution levels from anywhere using your computer or mobile. We can install this system anywhere and also can trigger some devices when pollution exceeds a certain level like we can turn on the exhaust fan or can send SMS / warning letters[1]. This research proposes an air pollution monitoring system. This system was developed using an Arduino microcontroller. Air pollution monitoring system is designed to monitor and analyze real-time air quality and log data to remote servers, keeping data updated via the internet. Air quality measurements were taken based on the Parts per Million (PPM) metric and analyzed using Microsoft Excel. The air quality measurements taken by the system designed are accurate. The results are displayed on a hardware interface that is designed and can be accessed via the cloud anywhere[6]. Experimental study on real-time air pollution monitoring using wireless sensors on public transport vehicles. The study is part of the GreenIoT project in Sweden, which leverages the Internet-of-Things to measure air pollution levels in downtown Uppsala. Through the deployment of low-cost wireless sensors, it is possible to obtain smoother, real-time levels of air pollution in different locations[7]. Industrial air pollution monitoring system based on wireless sensor network (WSN) PT technology. This system is integrated with the global system for cellular communication (GSM) and the communication protocol used is Zigbee. The system consists of sensor nodes, control centre and databases through which sensing data can be stored for history and future plans front [8]. Urban air quality monitoring system based on wireless sensor network technology (WSNs) which is integrated with the global system for cellular communication (GSM). The system consists of sensor nodes, gateways, and a control centre which are managed by the LabVIEW program to retrieve data that can be stored in a database. This system is deployed to the main roads in Taipei city unto monitor carbon monoxide (CO) concentrations caused by vehicle emissions. The experimental results indicate that the proposed system is suitable for real-time micro-scale air quality monitoring via WSN technology[9].

Technology in general can be carried anywhere practically and portable and easy to use to determine the quality of the air around us. This technology consists of 3 main parts, namely the sensor, rasberryPi3 +, and OLED which can be seen in Figure 1.

2. Methods

Industrialization and urbanization have caused widespread problems related to environmental pollution of water, air, and land [9]. The industrialization has also caused pollution in the zone above. Environmental responsibility and worker safety should be the main motto of any industry along with productivity and efficiency. This prototype (Fig.2) is to detect hazardous toxic gases and shows real-time monitoring of the concentration of gases on industrial floors [10]

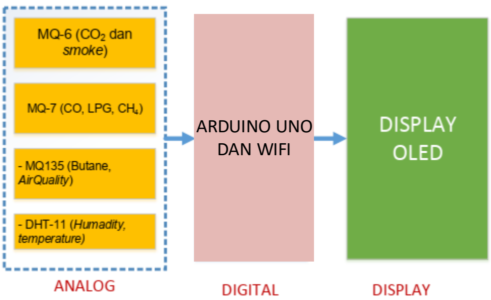

Fig 2. Data flow system

This concept uses three gas sensors, namely: MQ-6, MQ-7, MQ-135, and also use a DHT11 (temperature and humidity) sensor. The sensors can be embedded in hats, helmets, or watches that workers can wear. The introduction of flexible and lightweight sensors can further improve implementation[11]. The idea could be realized by introducing[2]. Raspberry-pi and an IoT shield. The idea of this research is to feel the level of air pollution and it will be sent to a Google spreadsheet and give an alarm warning if the gas level exceeds the allowable limit. With IoTShield, device manufacturers, system integrators, and IoT network operators can quickly secure and manage devices, without the need for any security expertise, without expensive development, and testing resources, and no changes to application code or device functionality[12].

IoTShield provides solutions for multiple application-level security layers and is ideal for the protection of gateways, industrial PCs, and Linux-based edge devices[8]. IoT protectors prevent damage to plan operations and protect connected IoT network components. An API (application program interface) can be activated which acts as a medium between the Raspberry-Pi and Google servers. It also permits sensors to write readings on the Google cloud web server by sharing the client's email id from (.json folder) which can be downloaded after enabling the API for google spreadsheet. MQ-6/7/135 Gas Sensor is one of a series of Gas Sensor semiconductors (Fig. 2) that can be used to detect gases mainly used for workshops and commercial buildings. It has many features such as high sensitivity, fast response, wide detection range, stable performance, and long life, simple drive circuit. This sensor resistance value varies with various gas concentrations. So, when using this component, sensitivity adjustment is necessary.

3. Results and Discussion

3.1. Basic Sensor Circuit and Calibration

Researching the air quality monitoring system with IoT produces a product, namely a tool to measure the condition of the air around us using 3 gas sensors, namely MQ 7, MQ 6, and MQ 135. The three sensors can measure dangerous gas conditions, namely MQ7 to measure CO levels (carbon monoxide), MQ 6 to regulate levels of C_4H_{10} (butane), and MQ 135 to measure levels of CO_2 (carbon dioxide) and NH_3 (ammonia) in the form of ppm (parts per million). The gas sensor needs to be calibrated so that it can be converted in the form of ppm. To be able to calibrate a gas sensor we must know the basic circuit diagram because each sensor product is different. Below are the most common and widely used products on the market.

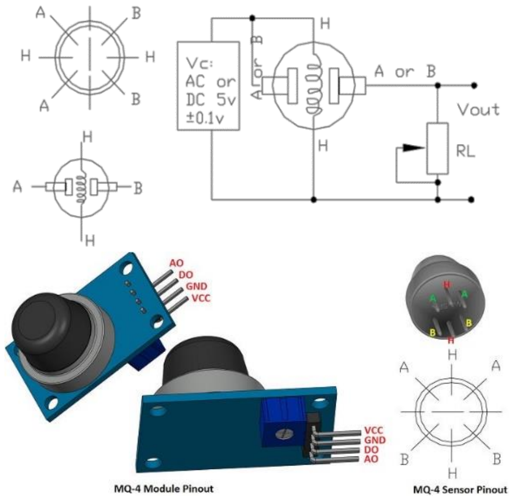

Fig .3 Basic Series of Gas Sensors

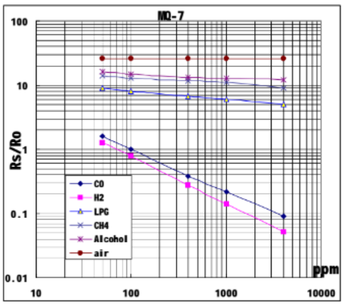

Fig. 4a. Ppm of Sensor MQ-7

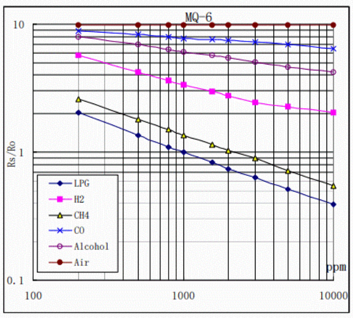

Fig. 4b. Ppm of Sensor MQ-6

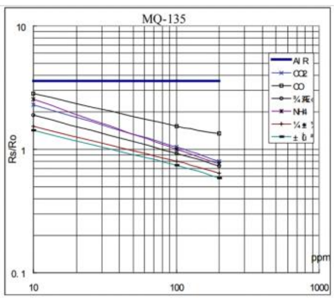

Fig. 4c. Ppm of Sensor MQ-135

From the graph above we can find out the ppm value by knowing Rs / Ro, where Rs is the sensor resistance at a certain CO level / which we are measuring and Ro is the sensor resistance in clean air with a CO level of 100ppm. The chart above was taken at 20^{0}C, 65% humidity, 21% oxygen concentration, and RL 10K Ohm. The data needed are Ro and Rs data to find out the level of CO in ppm, Ro here is for calibration, to equate the measurement results of our sensors with the actual results or at least with the results of measurements with standardized tools, so in this section, we ignore Ro first. Ro we will use later to calibrate the measurement results by changing the values.

Rs = (Vc x RL / V RL) - RL

Where,

Rs = Resistance to the sensor
Vc = Voltage entering the sensor
RL = Load resistance in the circuit
VRL = the output voltage of the circuit

The flowchart of the program in performing the calibration is as shown in Figure 5 below.

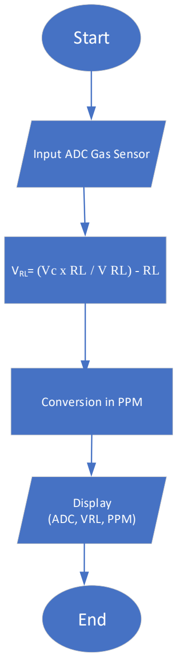

Fig 5. sensor calibration flowchart

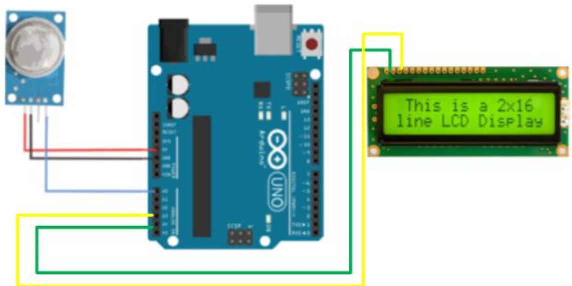

Fig. 6. Sensor circuit

Here are the results of sensor measurements to find CO, CO_2, NH_3, and C_4H_{10} in ppm units

Table .1 Sensor test results

Time	CO	CO_2	NH_3	C_4H_{10}
1 st minute	12.92	1.44	0.01	0
2nd minute	10.98	1.29	0.00	0
3rd minute	9.53	1.26	0.01	0
4th minute	8.71	1.29	0.01	0
5th minute	8.10	1.29	0.00	0
6th minute	7.60	1.24	0.01	0

Time	CO	CO_2	NH_3	C_4H_{10}
7th minute	7.27	1.32	0.01	0
8th minute	6.88	1.38	0.00	0
9th minute	6.57	1.38	0.00	0
10th minute	6.65	1.29	0.00	0

Primary pollutants are the carbon oxides (CO, CO_2), sulfur oxides (SO_2, SO_3) and nitrogen oxides (NO, NO_2, NO_3) compound resulting from photochemical reactions, particles (smoke, dust, asbestos, metals, oil, sulfate salts), inorganic compounds (HF, H_2S, NH_3, H_2SO_4, HNO_3), hydrocarbons (CH_4, C_4H_{10}) radioactive elements (Titanium, Radon), heat energy (temperature, noise).

Table 2. Gas Pollution Threshold

No	Type of Parameters	Unit	Maximum Level	Information
1	Karbon Dioksida(CO_2)	Ppm	9.0	8 Jam
2	Karbon Monoksida (CO)	Ppm	1000	8 Jam
3	Amoniak (NH_3)	Ppm	25	8 Jam
4	Butan (C_4H_{10})	PPM	1900	8 Jam

from the data above the monitoring system can be seen the quality of the surrounding air by looking at the hazardous gas threshold.

3.2. Primary circuit

his air quality monitoring block diagram is an illustration of the system work process consisting of the sensor part, the microcontroller part, the transmission part and the interface part as shown in Figure 7 below.

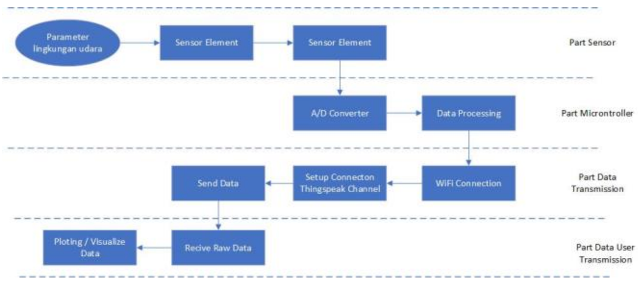

Fig. 7 Block diagaram system

This air monitoring and decision support system is in the form of a device that is connected to the internet and can monitor surrounding gases such as Carbon Dioxide (CO_2), Carbon Monoxide (CO), Ammonia (NH_3), Butan (C_4H_{10}) in ppm units. The following is a schematic image of the air quality monitoring system, where the system works by taking the sensor data to process the data to get Carbon Dioxide (CO2), Carbon Monoxide (CO), Ammonia (NH_3), Butan (C_4H_{10}) which is then sent to the server for display. and analyzed. The results of monitoring can be used in determining air quality.

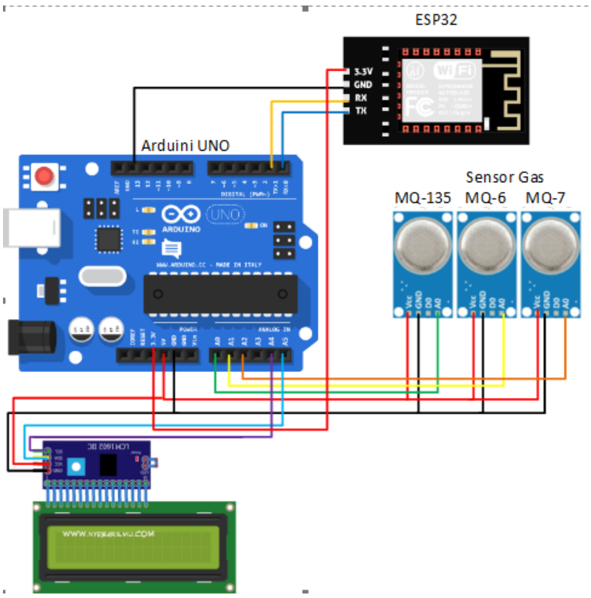

Fig 8. Basic Air Monitoring Sequence

Figure 8 shows that the circuit consists of: MQ-135 sensor, MQ-6 sensor, MQ-7 sensor, Arduino Mega, cable, 16x2 LCD, cable, and adapter. The following tools are required for multimeter, solder, and pliers. The circuit when tested in Figure 8.

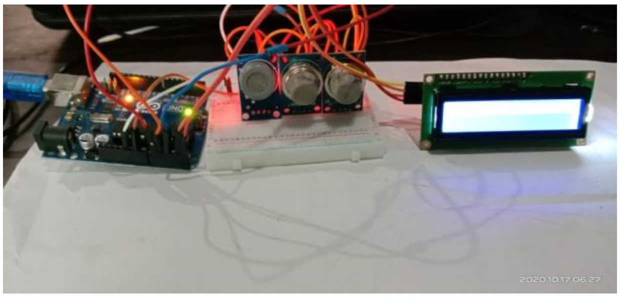

Fig. 8. Test circuit system

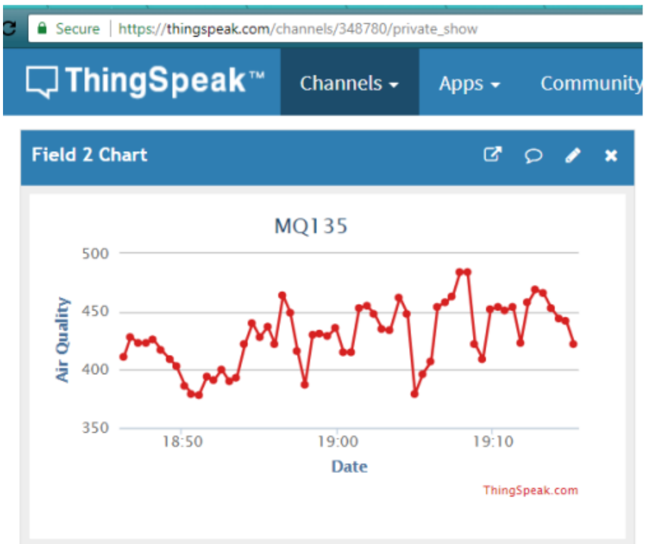

Fig.9. Monitoring using the web

Table 3. The following are the results of monitoring 24 hours a day

Times	CO	CO_2	NH_3	C_4H_{10}
1st hour	6.64	2.26	0.01	0
2nd hour	6.43	2.29	0.01	0
3rd hour	6.43	2.34	0.01	0
4th hour	7.13	2.89	0.02	0
5th hour	7.32	2.99	0.02	0
6th hour	8.27	3.32	0.02	0
7th hour	8.43	4.33	0.02	0
8th hour	8.47	4.76	0.02	0
9th hour	8.72	5.93	0.02	0
10th hour	7.87	5.87	0.03	0
11th hour	7.45	5.99	0.03	0
12th hour	8.42	5.98	0.03	0
13th hour	8.22	5.97	0.04	0
14th hour	6.87	6.32	0.04	0
15th hour	6.67	5.42	0.04	0
16th hour	7.22	6.13	0.04	0
17th hour	7.43	6.34	0.03	0
18th hour	7.33	6.63	0.03	0
19th hour	7.21	6.23	0.03	0
20th hour	6.45	5.44	0.03	0
21st hour	6.22	5.24	0.03	0
22nd hour	5.54	4.64	0.02	0
23rd hour	4.76	3.78	0.02	0
24th hour	3.98	3.34	0.02	0
Average	7.06	4.77	0.025	0

Table 3 above shows the current conditions at the location of Kelud Raya Street 2nd UTC Hotel Gajahmungkur Semarang. The condition when it starts at 00.00 (1st hour), the CO and CO_2 conditions are still low because the road conditions are still a little bit passing motorized vehicles, both wheels and wheels, after the peak when people go to work, namely 06.00 - 10.00, namely CO 8.42 and CO_2 6.32. When the lowest point at night is 00.01.

6. Conclusion

From the research above, it has been done that the level of measurement accuracy can be seen in the calibration which is carried out in a way, to equate the measurement results of our sensors with the actual results or at least with the results of measurements with standardized tools. The air monitoring conditions of CO, CO2, NH3, and, C4H10 depend on the time and the number of at least two-wheeled and four-wheeled motorized vehicles, which are peaks at 10:00 and 17:00 when leaving for work and returning to work.

References

[1] R. Nayak, M. R. Panigrahy, V. K. Rai, T. A. Rao, and B. Diagram, “IoT Based Air Pollution Monitoring System,” no. 4, pp. 571–575, 2017.

[2] M. R. Deshmukh, S. J. Chavan, R. A. Chavan, and P. G. Atarde, “IOT Based Air & Sound Pollution Monitoring System,” no. 3, pp. 750–753, 2018.

[3] A. M. Leman, “Occupational Safety and Health : Workers and Industrial Safety Monitoring For Sustainable Work Industrialisation and urban renewal has caused widespread problems relating to environments such Author Details :,” no. May, pp. 34–36, 2013.

[4] A. Kurniawati, “DIPONEGORO LAW REVIEW Volume 1, Nomor 2, Tahun 2013,” vol. 1. pp. 1–11, 2013.

[5] P. Y. Sai, “An IoT Based Automated Noise and Air Pollution Monitoring System,” vol. 6, no. 3, pp. 419–423, 2017, doi: 10.17148/IJARCCE.2017.6397.

[6] K. Okokpujie, E. Noma-osaghae, and M. Odusami, “A SMART AIR POLLUTION MONITORING,” no. October, 2018.

[7] S. Kaivonen and E. Ngai, “AC,” *Digit. Commun. Networks*, 2019, doi: 10.1016/j.dcan.2019.03.003.

[8] G. Swagarya, S. Kaijage, and R. S. Sinde, “Air Pollution Monitoring System based on Wireless Networks - Simulation,” vol. 5, no. 8, pp. 9–16, 2014.

[9] C. Chen, T. Wen, C. Sun, and J. Juang, “A Community Health Service Architecture Based on the Internet of Things on Health-Care,” no. April 2015, 2017, doi: 10.21307/ijssis-2017-477.

[10] B. Carter and R. Ragade, “Message Transformation Services for Wireless Sensor Networks (MTS-WSN),” no. January 2006, 2014.

[11] A. Nag, S. C. Mukhopadhyay, and J. Kosel, “Wearable Flexible Sensors : A Review,” no. c, 2017, doi: 10.1109/JSEN.2017.2705700.

[12] J. Blum, *Exploring Arduino: Tools and Techniques for Engineering Wizardry*. .