IoT based Air Quality Monitoring

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Abstract. Air pollution is a mixture of solid particles and gases in the air. Car emissions, chemicals from factories, dust, pollen and mold spores may be suspended as particles. Effect of air pollution has many bad things and the others may cause problems to our health, for instance, asthma, cough, and lung disorders. In addition, the pollutant can cause global warming, acid rain, and disturbing plant growth. Basically, a human cannot determine whether the air is good or not. Hence, it is necessary to have a tool that can measure the air quality. This research is purposed to design an air quality monitoring system by utilizing esp8266 module. As the result, users can monitor the air condition using smartphone connected through ESP8266 Wi-Fi. Therefore the air condition can be monitored every time. Currently, there is so much air pollution cases that actually can be changed if we are aware. In other words we can contribute as part of the solution instead part of the pollution.

1. Introduction

Nowadays the air condition is very polluted. In recent years, car emissions, chemicals from factories, smoke and dust are everywhere. That is the reason why now air condition is very polluted. The effect of air pollution is very bad for our health, especially for place where the air in our body is taken for breathing. In our lungs may cause some diseases, such as asthma, cough, lung disorders[1].

The air pollution cannot be detected by human feelings. The air pollution may contain a lot of dangerous substances, such as LPG gas, smoke, carbon monoxide, methane[2]. Substances in the polluted air are very dangerous. For example, if the carbon monoxide is above 100ppm, it makes human feel dizzy, nauseous, and within minutes they could die.

This research makes human find out which content of the air is polluted. With module nodemcu esp8266, we can monitor the air pollution remotely, because there is a Wi-Fi in nodemcu esp8266. This makes the air condition can be monitored every time.

2. Method

In this research, nodemcu esp8266 is used as the micro controller. This board has Wi-Fi module that acts as the internet connector and information accessing for the air quality[3]. This is the reason why this board is chosen as some of tools for this research, besides the price of this board is very cheap as well. This is the input pin and picture of nodemcu esp8266:
In addition, the tools which are needed in this research as in Table 1.

### Table 1. Tools of air quality monitoring

1. Nodemcu ESP8266
2. MQ2 gas sensor
3. MQ9 gas sensor
4. Analog Multiplexer 4051 (CD4051BE)
5. 1.3 inches OLED monitor SSD1306
6. 180ohm resistor x2 and 330 ohm resistor x2
7. Adapter 5v
8. ZH03A Laser Dust Sensor

This project is to integrate 3 sensors that detect different kinds of gases and particles with Nodemcu before the data detected is sent to the internet. The 3 sensors are MQ2, MQ9 sensor for carbon monoxide and zh03a particle sensor for PM1.0, PM2.5 and PM10 (dust).

MQ2 sensor module is used for gas leakage detection (home and industry). It is suitable for detecting H2, LPG, CH4, CO, Alcohol, Smoke or Propane. Due to the high sensitivity and fast response time of it. But, in this design, we used MQ2 sensor for smoke situation. This sensor has four outputs, namely, Vcc, ground, D0, and A0. Not all outputs will be connected to nodemcu. However, only D0 that is not connected to nodemcu because this sensor only can choose one output A0 or D0.
The same features with the MQ2 sensor, MQ9 sensor is sensitive and also fast response time. This sensor is suitable for detecting H2, LPG, CH4, CO, Alcohol, Smoke or Propane. The utilization is for detecting the Carbon Monoxide (CO). The shape of this MQ9 is the same as the sensor MQ2, but it is bigger than MQ2[4]. For the output of this sensor, it is same with MQ2 output.

The last sensor is ZH03A, that is, dust sensor. ZH03A module is a common type, it is a small size sensor that uses laser scattering principle to detect the dust particles in air, with good selectivity and stability[5]. ZH03A has eight pins, but only four pins are needed to be connected to nodemcu. Those are vcc, ground, rx, and tx.
Figure 4. ZH03A dust sensor

The diagram in Figure 5 shows how this research works:

Figure 5. Diagram of How Research Works

Nodemcu as a microcontroller will send the result of sensor readings to LCD and Internet. The internet connection can be served from smartphone tethering or router internet. Thinkspeak is used as media to read the results from nodemcu. As long as nodemcu connects to the Internet, the result readings can be monitored every time.
The picture in figure 6 shows the connection of all different components. One drawback of Nodemcu is it only has one analog I/O pin. In this project, there are 2 sensors, those are MQ2 and MQ9 gas sensor that use an analog output. In this case, a technique called multiplexing can be used. Instead of reading output from 2 sensors at the same time, the data is read one by one. In this project, an analog multiplexer CD4051BE is used. It is a 8-channel multiplexer which can operate with 8 outputs.

Another drawback of Nodemcu is that it only supplies 3.3 V output. While, for other components and three sensors used in this project, they need 5V power supply to operate. Therefore, the adapter 5 V was used to source of all sensors. The analog output of MQ2 and MQ9 are between 0V to 5V whereas the analog pin of node MCU is only able to read between 0V to 3.3V. This means that node MCU cannot read the data if MQ2 or MQ9 sensor output is above 3.3V. The data read is not accurate. Therefore, voltage is needed step down.

In this research, voltage divider by two resistors was used. The voltage output is determined by the ratio of the value of two resistors, 180 ohm as R1 and 330 ohm were used as R2 so that Vout is 3.3V. So, Vin is connected to AO pin of MQ gas sensors while Vout is connected to channels of the multiplexer[6].
Multiplexer connection:
- Vdd (pin 16) to 5V supply
- INH, VEE, VSS (pin 6, 7, 8) to nodemcu GND pin
- Common out/in (pin 3) to nodemcu A0 pin
- A, B, C (pin 11, 10, 9) to nodemcu D0, D1, D2
  A, B, C (pin11, 10, 9) are used to select channel. 3-digit binary number is formed in the order of CBA. As we use channel 1 and 2, binary number of 1 and 2 in 3-digit binary number are 001 and 010 respectively. Therefore, when we want output of channel 1, then D0 output 1, D1 and D2 output 0. When we want output of channel 2, D0 output 0, D1 output 1 and D2 output 0.

After all parts are ready to combine, we need PCB to make the board simpler and easier. If PCB is not used, then the flow of current may be disturbed, making all sensors does not work. We use Arduino IDE for software side. But, first nodemcu board must be downloaded first.

![Figure 8. PCB Circuit](image)

When nodemcu connects to internet, nodemcu will send the result of monitoring to thingspeak. ThingSpeak has APIs for collecting data produced by sensors and reading the data from applications[7].

3. Result and Discussion
Last step after wiring all parts to PCB board is covering all parts with the box. All sensors must be contacted to the air directly. The box needs to drill until the sensors and LCD fit with the box. And then, all parts seem good looking with the box. The dimension of box is 18 cm x 11 cm x 6 cm. The Figure 9 shows the front and rear view of the box. It can be seen, the box is not too small nor too big as well, so the box is easy to carry anywhere.
Next, we will illustrate the result of the measurement from sensors. The data is taken from the measurement of a cigarette:

**Figure 9.** Box of air quality monitoring

**Figure 10.** Results of smoke content readings

**Figure 11.** Carbon monoxide reading results

**Figure 12.** Results of PM1 Reading

**Figure 13.** Results of PM2.5 Reading

**Figure 14.** Results of PM10 Reading
The results show that if the red line is upward, the particle level of pollution is higher and dangerous. At level 0-50 ppm, healthy air falls into the healthy category, while in the range 50 – 100 ppm is categorized medium air (no effect on health). The range of 100-200 ppm, air is not healthy, 200-300 ppm is very unhealthy, while 300 upwards is said to be very dangerous [8]. As shown in figure 10, the smoke point indicates that the smoke level is above 10k, indicating that the ambient air condition is very dangerous.

Carbon monoxide (CO) when inhaled into the lungs will participate in blood circulation and will block the entry of oxygen needed by the body. This can happen because CO gas is toxic metabolism, participating to react metabolically with blood. Like oxygen, CO gas readily reacts with blood (hemoglobin) [9]. Figure 11 shows that no CO content contained in cigarettes, indicating that there is no CO content in the air.

Air pollution problems generally are caused by solid particles of TSP (Total Suspended Particulate or total drift particle) with a maximum diameter of about 45 mm, particles of PM10 (particulate matter) with diameters less than 10 mm and PM2.5 with diameters less than 2.5 mm. These particles are believed by environmental and public health experts to trigger respiratory infections, because solid particles of PM10 and PM2.5 can precipitate in the respiratory tract of the bronchi and alveoli areas, whereas TSP cannot be inhaled into the lungs, but only at upper respiratory tract [10]. Figure 15 shows that the ppm content is almost 500, implying that the air is dangerous and Figure 16 illustrates that the air condition is dangerous because the ppm content is almost 1000.

4. Conclusion
An air quality detector is very important because nowadays air pollution is easy to find. For the air pollution which cannot be easy detected by human, it requires a device as a reader of the air quality. By this research, we can avoid air pollution through monitoring the air quality regularly.

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