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Economically Air Quality Monitoring System Using NodeMCU

Nurfadzilah Ahmad[1], Habibah Zulkefle[2], Puteri Sarah Mohamad Saad[2], Sivaraju S. S[3], Nurdiyana Borhan[4], Wan Abd Al-Qadr Imad Wan Mohtar[5]

[1]Solar Research Institute (SRI), Universiti Teknologi MARA (UiTM) Shah Alam, Selangor, [2]School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA (UiTM) Shah Alam, Selangor, [3]RVS College of Engineering and Technology, Coimbatore, Tamil Nadu, India, [4]Davex (Malaysia) Sdn. Bhd., Subang Jaya, Selangor, [5]Functional Omics and Bioprocess Development Laboratory, Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603, Kuala Lumpur, Malaysia

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Abstract

The aim of this research is to examine the monitoring systems for air quality, their supporting technologies and protocols. Due to its notable impact on society health and the global economy, the primary concern is air quality, particularly in modern cities. The importance of the data on air quality makes the very reliable real-time monitoring systems important. The limited data access, high cost and non-scalability of the traditional air monitoring system enforces researchers to build potential air quality monitoring systems using emerging technologies such as NodeMCU, Internet of Things (IoT) and low-cost environmental sensors. In addition, the present study discussed the challenges, foundations and methods of developing a framework for tracking air pollution in real time using IoT technologies. Finally, the analysis addressed the limitations of current works and outlined the targets to be met in future air monitoring systems in order to make them more reliable and practical.

Keywords: Air Quality, Internet of Things (IoT), NodeMCU

Introduction

Over the past few decades, airborne diseases and the number of deaths each year have increased gradually. This has also caused respiratory issues such as asthma attacks, inflammatory rashes in the blood and skin, Chronic bronchitis, chronic lung conditions and coronary heart disease (Liu et al., 2020). It is attributed to the excessive emission of air pollutants, such as smoke, poisonous gasses from automobiles and factories.

Not only has air pollution, worsening air quality and increased airborne particulate matter affected human health, but have also caused significant environmental issues, including low visibility, inadequate weather patterns, acid rain, global warming and other shifts in the atmosphere (Chojer et al., 2020). The main cause of air pollution worldwide is due to smoke & gases released from vehicles while processing is the second main source of air pollution. The heavy use of cars in towns has contributed to a rise in ambient greenhouse gases.

Similarly, other sources of pollution, such as smog, carbon monoxide, ammonia, methane, nitrogen dioxide, sulphur dioxide and other greenhouse gases, have low visibility and adverse environmental impacts (Lee et al., 2020). Owing to their smaller size and invisibility these contents are usually missed by men. Significant human, animal, climate, and water impacts are caused by this type of negligence. Consequently, the need for an environmental pollution monitoring programme is growing day by day to protect individuals from these adverse effects. Citizens in different countries are also unaware of the shortcomings of this issue.

Airborne particulate matter (PM) is commonly accepted as an air quality concern. In different countries the Air Quality Index has different indications. The norm in the US is based on five contaminants such as PM2.5, PM10, ozone, sulphur dioxide and nitrogen dioxide (Miñarro et al., 2020). In addition to uploading to the IoT cloud, the aim of data monitoring and collection is to provide scientists, government and policy makers with the expertise to provide solutions for environmental change. The study emphasizes on the importance of monitoring the air quality at different places, which are the outdoor residential area, the indoor ambient and factory ambient. Avoiding the improper air quality places gives benefit to human health and is a prevention from getting sickness such as flu and lung infection, and hence the medical cost will be reduced.

Methodology

A. Flow chart

The Air Pollution Monitoring System is based on the flowchart as shown in Figure 1. Emission level data is recognised by the gas sensor MQ135. NH3, NOx, alcohol, Benzene, smoke, CO2, SO2 etc can be detected by the MQ135 sensor. Thus, the Air Quality Monitoring System is a complex gas sensor. It will sense all gases when linked to NodeMCU, and it will send the amount of pollution.

The need for ESP8266 was met by NodeMCU. It binds the device to ThingSpeak. Thing Speak is an empirical IoT system. A platform service that aggregates, visualises and analyses the cloud's live data streams. ThingSpeak offers instant awareness visualisations posted to ThingSpeak by devices.

The safety standard of pollution is up to 400 PPM and should not reach 1000 PPM. It can cause headaches, sleepiness and stagnant, stuffy air when it reaches the limit of 1000 PPM. It can cause elevated heart rate and several different diseases if it reaches 2000 PPM (Demanega et al., 2021). If the number is above the recommended level, the buzzer will start beeping and thus send a smartphone warning message via an application named Blynk and "Air quality is bad" will be displayed.

Blynk is an IoT programme used to control Arduino, Raspberry Pi and thus the likes of the internet. In this project, Blynk provides a smartphone with a digital dashboard that shows real-time air quality values for the immediate environment. The Figure 2 shown is the block diagram of the system.

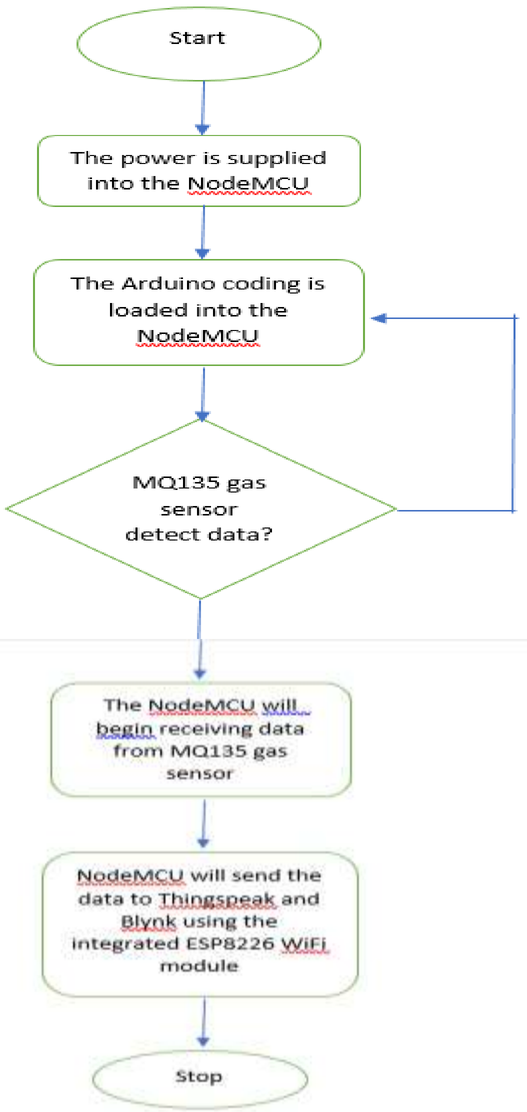

Figure 1: Flowchart of Air Pollution Monitoring System

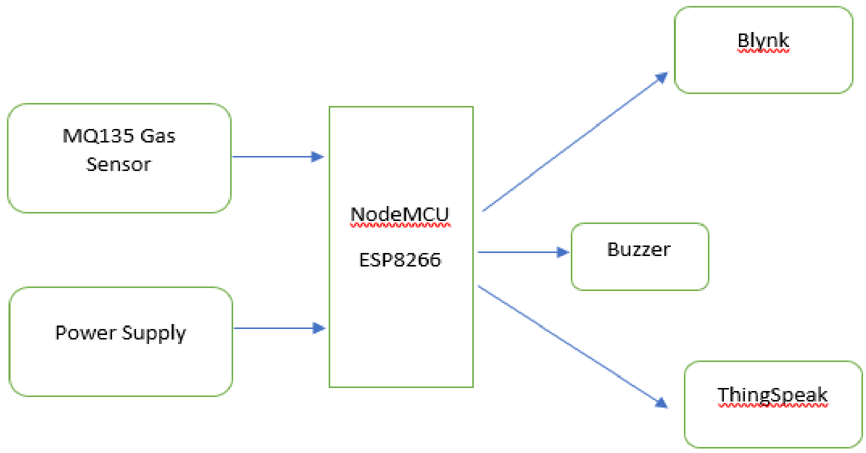

Figure 2: Block Diagram of Air Pollution Monitoring System

B. Material and Component

Two key components, the NodeMCU ESP 8266 and the MQ135 gas sensor, were used to collect the data. The NodeMCU ESP8266 is a WiFi module used in this study to move data to a server using the Internet of Things (IoT). Figure 3 shows the NodeMCU 8266.

Figure 3: NodeMCU 8266

SnO2 is the sensitive material used in the MQ135 gas sensor. There is lower conductivity of this substance in clean air. With the rise in target gas emission concentrations, the sensor's conductivity increases. MQ135 can be tracked by different forms of toxic gases such as sulphide, ammonia gas, benzene series steam and CO2. The detection range along the way ranges from 10-10,000 ppm. Figure 4 demonstrates the gas sensor MQ135.

Figure 4: MQ135 Gas Sensor

The assembled hardware is shown in figure 5 below.

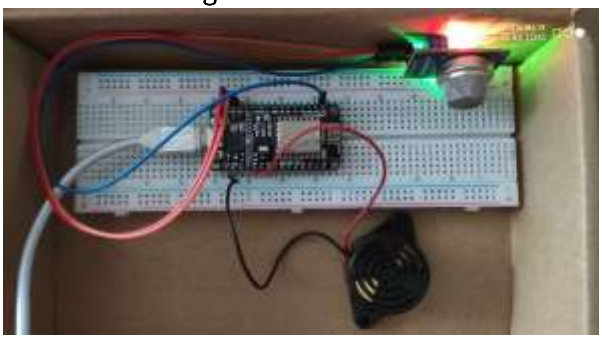

Figure 5: The assembled hardware

C. Software and Coding

The software used to make the coding is by using Arduino IDE. It is one of the simplest coding software there is. The software is easy to use and can do a lot of different things. Figure 6 and 7 shows the coding of the system.

```
#include <SimpleTimer.h>
#include <ThingSpeak.h>
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <MQ135.h>

#define BLYNK_PRINT Serial      // debugging for blynk
char auth[] = "8DpSQjC6RuJFaL3yDnpiQF3uYJHCX8Om"; // token generated by blynk app

String apiKey = "NE2U2P5HMEVVBOIG"; // thingspeak channel
const char* server = "api.thingspeak.com";

char ssid[] = "free_wifi_258unifi"; /// WiFi details
char pass[] = "ar8716208@";

SimpleTimer timer; // timer
WiFiClient client; //client that can connect to to a specified internet IP address

int mq135 = A0; // sensor is connected with the analog pin A0
int data = 0;
const int buzzerPin = 15; // buzzer

void setup()
{
  // for blynk //

  Serial.begin(115200); // serial rate is 115200
  Blynk.begin(auth, ssid, pass); // blynk to connect to wifi
  timer.setInterval(1000L, getSendData); // new data will be updated every 1 sec
  pinMode(buzzerPin, OUTPUT); // Set buzzer - D8 on nodemcu

 // for thingspeak //

  Serial.begin(115200);//set baudrate 115200 on the serial monitor
  delay(10);//give delay of 10milliseconds
  Serial.println("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, pass);
  while (WiFi.status() != WL_CONNECTED)//indicate that nodemcu was connected to wifi
  {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");

}

void loop()
{
  // for blynk //

  timer.run(); // Initiates SimpleTimer
  Blynk.run(); // Initiate Blynk
```

Figure 6: The coding of the system

```
timer.run(); // Initiates SimpleTimer
Blynk.run(); // Initiate Blynk

// for thingspeak //

  MQ135 gasSensor = MQ135(A0);
  float air_quality = gasSensor.getPPM();
  Serial.print("Air Quality: ");
  Serial.print(air_quality);
  Serial.println("  PPM");
  Serial.println();

if (client.connect(server, 80)) // "184.106.153.149" or api.thingspeak.com
{
  String postStr = apiKey;
  postStr += "&field1=";
  postStr += String(air_quality);
  postStr += "\r\n";

  client.print("POST /update HTTP/1.1\n");
  client.print("Host: api.thingspeak.com\n");
  client.print("Connection: close\n");
  client.print("X-THINGSPEAKAPIKEY: " + apiKey + "\n");
  client.print("Content-Type: application/x-www-form-urlencoded\n");
  client.print("Content-Length: ");
  client.print(postStr.length());
  client.print("\n\n");
  client.print(postStr);
  Serial.println("Data Send to Thingspeak");
}
  client.stop();
  Serial.println("Waiting...");

  delay(1000);         // thingspeak needs minimum 15 sec delay between updates.
}
/***************************************************
 * Send Sensor data to Blynk
 **************************************************/
void getSendData()
{
data = analogRead(mq135);
  Blynk.virtualWrite(V2, data); // connected to virtual pin V2 in Blynk app

  if (data > 200)
  {
    tone(buzzerPin, 1000); // Send 1KHz sound signal...

    delay(1000);          // ...for 1 sec

    noTone(buzzerPin);        // Stop sound...

    delay(1000);          // ...for 1sec

    Blynk.notify("Air level is bad");
  }
}
```

Figure 7: The coding of the system

Results and Discussion

The pollutant levels in the selected area were provided by the IoT-based Air Quality monitoring system and the data was uploaded to the Thingspeak cloud. We can clearly saw and compared the level of contaminants with the standardised values specified for the environment in terms of ppm (parts per millions) in the following graphs shown in Figures 8-10. This has made it easier for people to be educated about the air quality and the amount of pollution in their region and to become aware of them. This system can be commonly used in workplaces, warehouses, suburban areas and institutions of business and education. Because the system is not that complex, it can therefore be used 24 hours a day.

A. Outdoor Ambient Residential Area Air Quality

The air quality of residential area was measured as shown in Figure 8. Figure 8 shows the graph of the outdoor ambient residential area air quality in PPM. The specific area involved during the data collection process were the backyard area, in front of the house area and the garden of the residential area. The data was taken in the interval of 5 minutes and it shows that the air quality is between 250 to 300 ppm (parts per millions) which is considered normal background ambient for outdoor area. The air quality in the area is considered very healthy (Cruz et al., 2019).

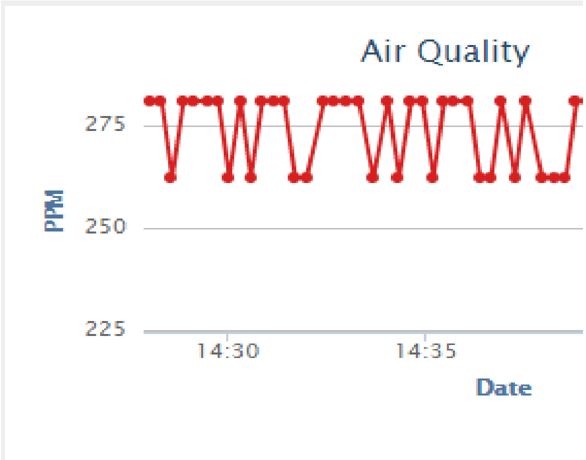

Figure 8: Outdoor residential area air quality

B. Occupied Indoor Spaces with Good Air Exchange Air Quality

The air quality of indoor spaces was also measured. Figure 9 shows the graph of the air quality of occupied indoor spaces with good air exchange. During data collection process, the specific area was filled with people to show that there is carbon dioxide (CO2) gas that was released in a quite tight indoor space. The air quality was measured between 700 to 800 ppm in time interval of 5 minutes. The air quality was slightly higher than outdoor area because of CO gas that was released by the occupants of the indoor area, but it is still considered a good air exchange (Cruz et al., 2019).

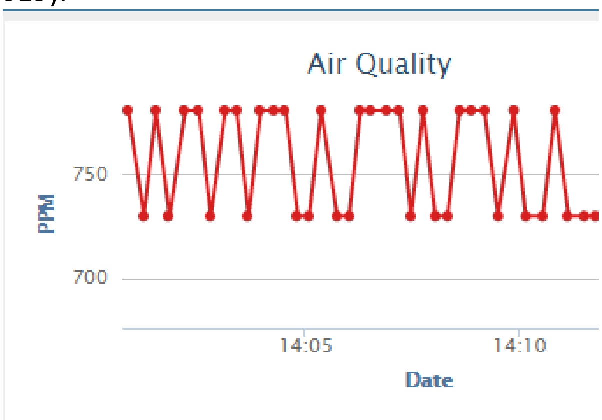

Figure 9: Occupied indoor spaces with good air exchange air quality.

C. Factory Area Air Quality

The air quality of factory area was measured. Figure 10 below shows the graph of air quality in factory area. During data collection process the factory was in working hours and the data collection was taken near the factory and the findings of the air quality was between 1050 to

1200 ppm in between the interval of 2 minutes which was above the recommended level and it is considered a poor air quality. This level of air quality could lead to a complaint of drowsiness (Lu et al., 2021; Reddy N & Students, n.d.).

Figure 10: Factory area air quality

Lastly, the average ppm of all the three areas had been shown as in Figure 11 below. We can conclude the findings that the highest ppm between all the three areas is the factory area with 1150 ppm (*Design and Implementation of Arduino Based Air Quality Measurement Meter with Digital Dashboard on Smartphone Using Blynk*, n.d.; Sai et al., 2019).

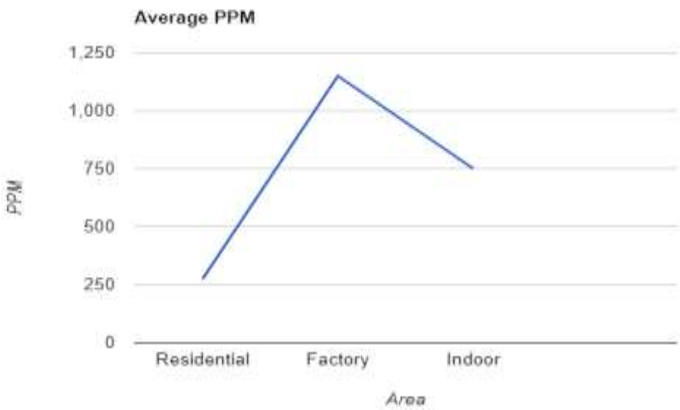

Figure 10: The average PPM of all three areas

Conclusion

In conclusion, this project offers a cheap and smart way of monitoring the atmosphere and air pollution as a low-cost yet effective and embedded device. Functions of various sensors and their working processes were explored in the proposed architecture. The main reason of this study is to explore the air quality of different places, which are the outdoor ambient residential, indoor space, and factory area. How it functions, features, best uses and procedures for data taking were also addressed. The air pollution control system will be checked in various parts of the world for the monitoring of gas levels. It sent the parameters of the sensor to the data server as well. The project system showed that it is powerful and inexpensive and can really be a reliable one for anyone with some highly functional sensors and its data will be a key to taking some necessities. On the other hand, apart from the low cost of the monitoring system using NodeMcu, the medical cost will also be reduced due to the reduction of diseases caught from inhaling the dirt from the air.

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