

Air Pollution Detection in Surrounding with the Help of IOT

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Article History:

Received: 14-05-2024

Revised: 23-06-2024

Accepted: 07-07-2024

Abstract:

This research presents the development of an air pollution meter using the MQ135 gas sensor and NodeMCU ESP8266 microcontroller. The sensor measures the concentration of harmful gases such as carbon dioxide, ammonia, and nitrogen oxides in the air, and sends the readings to the microcontroller. Using programming code, the raw readings from the sensor are converted to parts per million (PPM) values, which are more meaningful for air quality monitoring. The NodeMCU ESP8266 connects to a ThingSpeak server through Wi-Fi to transmit the PPM values in real-time. The server stores and displays the data on a graphical dashboard, allowing users to monitor air pollution levels in their vicinity. The project demonstrates the feasibility of low-cost and efficient air quality monitoring using readily available hardware and software tools. The results of the experiments show that the developed air pollution meter can provide accurate and reliable measurements of various air pollutants, thus contributing to environmental sustainability and public health.

Keywords: Air Pollution, Internet of Things, MQ 135 Sensor, Parts per Million.

1. Introduction

Air pollution is a critical issue that affects the environment and human health. With the increasing level of air pollution, there is a need for reliable, real-time monitoring systems that can provide accurate and timely data on the quality of the air. This research work focuses on the design and implementation of an air pollution monitoring system using NodeMCU and MQ 135 sensor[1].

NodeMCU is a microcontroller that provides an easy and reliable way to connect devices to the internet. The MQ 135 sensor is a gas sensor that can detect a wide range of air pollutants, including carbon dioxide, ammonia, and smoke. The sensor provides analog output that can be read by the NodeMCU to provide real-time data on the air quality. The research work involves the development of a software system that can read the data from the sensor, process it, and display and store the data on a cloud service[2].

The implementation of the system involves the selection and calibration of the MQ 135 sensor, designing the NodeMCU firmware to read the data from the sensor, and using cloud system to display the real-time data. The system is tested and validated in different environmental conditions to ensure the accuracy and reliability of the data. Overall, the air pollution monitoring system using NodeMCU and MQ 135 sensor is an effective and efficient way to monitor the air quality in real-time[3].

The system can help in identifying the sources of air pollution, tracking the changes in air quality over time, and providing information to policymakers to take appropriate actions to improve air quality.

The meter calculates the air quality in parts per million (PPM), which is then compared to the given healthy level of the air quality[4].

Wireless gas leak detection and localization by Chraim, Erol, and Pister (2016) proposes a wireless sensor network for gas leak detection and localization. The network consists of a set of sensor nodes that are deployed in the area where gas leaks are likely to occur [5].

Intelligent control systems for carbon monoxide detection in IoT environments by Nandi, Debnath, and Debroy (2019) proposes an intelligent control system for carbon monoxide detection in Internet of Things (IoT) environments. The system consists of a set of carbon monoxide sensors, a controller, and an actuator. The sensors detect carbon monoxide levels, the controller processes the sensor data, and the actuator takes action to mitigate the carbon monoxide levels. Low-cost air quality sensing process: Validation by indoor-outdoor measurements by Motlagh et al. (2020) presents a low-cost air quality sensing process that is validated by indoor-outdoor measurements. The process consists of three steps: (1) data collection, (2) data processing, and (3) data analysis. The data collection step involves collecting air quality data from low-cost sensors. The data processing step involves processing the collected data to remove noise and outliers. The data analysis step involves analyzing the processed data to identify air quality trends[6].

Toward massive scale air quality monitoring by Motlagh et al. (2020) discusses the challenges and opportunities of massive scale air quality monitoring. The authors argue that low-cost air quality sensors can be used to achieve massive scale air quality monitoring. However, they also point out that there are a number of challenges that need to be addressed, such as sensor calibration and data quality assurance. Low-cost outdoor air quality monitoring and sensor calibration: A survey and critical analysis by Concas et al. (2021) provides a survey of low-cost outdoor air quality monitoring and sensor calibration. The survey covers a range of topics, such as sensor types, calibration methods, and data processing techniques. The authors also discuss the challenges and limitations of low-cost outdoor air quality monitoring. A review of low-cost particulate matter sensors from the developers' perspectives by Alfano et al. (2020) provides a review of low-cost particulate matter sensors from the developers' perspectives. The review covers a range of topics, such as sensor types, sensor performance, and sensor applications. The authors also discuss the challenges and opportunities of developing low-cost particulate matter sensors[7].

A survey by Marco and Gutierrez-Galvez (2012) gives an audit of flag and information handling for machine olfaction and chemical detecting. The audit covers a run of points, such as flag securing, include extraction, and classification. The creators too examine the challenges and openings of machine olfaction and chemical detecting. From low-cost sensors to high-quality information:

An outline of challenges and best practices for successfully calibrating low-cost particulate matter mass sensors by Giordano et al.[8]. (2021) summarizes the challenges and best practices for successfully calibrating low-cost particulate matter mass sensors. The creators contend that appropriate calibration is fundamental to guarantee the precision of low-cost particulate matter mass sensors. Cleverly calibration and virtual detecting for coordinates low-cost discuss quality sensors by Zaidan et al. (2020) proposes an cleverly calibration and virtual detecting approach for coordinates low-cost discuss quality sensors[9]. The approach employs a combination of physical and virtual sensors to move forward

the precision of discuss quality estimations. Field assessment of low-cost particulate matter sensors in tall- and low concentration situations by Zheng et al. (2018) reports the comes about of a field assessment of low cost particulate matter sensors in tall- and low-concentration situations. The comes about appeared that low-cost particulate matter sensors can be utilized to degree particulate matter levels in both tall- and low-concentration environments[10].

2. Literature Survey:

The paper portrays a framework that employments Discuss Quality Sensors, Gas Sensors, and Hub microcontroller unit sheets to mechanize and make the discuss quality checking prepare more intuitively. The framework can be put totally different areas to gather readings of distinctive gasses show within the discuss, which are at that point overhauled on the cloud. The information is shown in a versatile app and can be advance dissected to get it the discuss quality agreeing to the recorded region[11]. The paper proposes a device for monitoring air toxicity using NodeMCU and IoT technology. The device uses the MQ135 sensor to detect hazardous gases, and NodeMCU is used to control the entire process. A Wi-Fi module is used to connect the device to the internet and a monitor is used to display web pages over the internet, allowing for remote monitoring and control of the air quality[12]. The research proposes a smart air pollution monitoring system that continuously monitors air quality in an area and displays the measurements on an LCD screen. The system also sends the data to the "Thing speak" platform, allowing for real-time monitoring of air quality[13].

The research proposes a system that uses Node MCU and IoT technology to monitor air toxicity and control various gases in the atmosphere. The system employs an MQ135 sensor to sense hazardous gases and a Wi-Fi module to connect to the internet for remote monitoring. The researchers suggest using two or more sensors in the future for even more comprehensive air quality monitoring. The research proposes an air pollution monitoring system using ESP32 microcontroller and IoT technology to sense toxic gases and monitor air pollution levels through Blynk application. The system utilizes MQ135, MQ2, MQ5, and DHT11 sensors and yields an accuracy rate of 97%. The system can be further enhanced by adding sensors to monitor pollution levels of other harmful gases[14].

The paper surveys the state-of-the-art in sensor calibration for air pollution monitoring deployments. It discusses the different types of errors that can occur in air pollution sensors and the different approaches to calibration. It also discusses the challenges of calibrating air pollution sensors in the field[15].

Existing field calibration methods are often not robust to sensor drift and environmental variability. The proposed field calibration method is more robust to these challenges. The proposed field calibration method can be used to improve the accuracy of air quality measurements from smart air quality monitors[16].

There has been a growing interest in the development of low-cost indoor air quality monitoring devices. The challenges of developing low-cost devices can be addressed by using new sensor technologies and by optimizing the design of the devices. Low-cost indoor air quality monitoring devices can be used to improve the monitoring of indoor air quality and to help people to improve their health and well-being[17]. The use of sensors that are integrated with other devices, such as smartphones and wearables. This will allow people to monitor their own air quality exposure and to

take steps to improve it. The use of sensors that are powered by renewable energy sources, such as solar power. This will make it possible to deploy sensors in remote areas where there is no access to electricity. The use of sensors that are connected to the cloud. This will allow data from the sensors to be collected and analyzed in real time, which will help to improve the timeliness of air quality alerts[18].

The paper is well-written and the comes about are clearly displayed. The creators have done a great work of clarifying the challenges of compensating for benchmark float in micromachined warm wind sensors and the proposed strategy could be a promising approach. The paper is pertinent to the field of MEMS sensors and it may well be of intrigued to analysts and engineers who are working on the advancement of micromachined warm wind sensors. The benchmark float is caused by the distinction in warm conductivity between the sensor chip and the bundling substrate. The lumped parameter show is utilized to anticipate the benchmark float as a work of the sensor chip estimate, the bundling substrate estimate, and the warm conductivity of the two materials. The exploratory comes about appear that the proposed strategy can viably compensate for the benchmark drift[19]. The paper proposes a novel strategy for real-time IC maturing expectation by expanding the forecast plans to a comprehensive demonstrate which takes under consideration any time-variant energetic working conditions important to maturing prediction. The strategy is based on machine learning and it employments a bolster vector relapse (SVR) demonstrate to anticipate the IC aging. The strategy is approved utilizing exploratory results[20]. The paper proposes a strategy for sensor float calibration in savvy buildings that leverages spatial relationship between sensors. The strategy employments a Kalman channel to appraise the float of each sensor and a spatial relationship demonstrate to progress the precision of the estimation. The strategy is approved using experimental results[21].

The paper examines the achievability of utilizing low-cost sensors for contamination hot-spot detection. The creators conducted a 44-day estimation campaign in a city in Finland and compared the estimations from low-cost sensors to those from reference sensors. The comes about appeared that the low-cost sensors were able to distinguish contamination hot spots with a tall exactness. The paper presents the advancement and assessment of a palm-sized optical PM_{2.5} sensor. The sensor is based on the rule of light scattering. The sensor was assessed in a research facility setting and in a field setting. The comes about appeared that the sensor is able to degree PM_{2.5} concentrations with a tall accuracy[22]. The paper presents a Bayesian intermediary demonstrating approach for assessing dark carbon (BC) concentrations utilizing white-box and black-box models. The white-box demonstrate may be a physical demonstrate of the atmosphere, and the black-box model could be a measurable show that's prepared on data. The Bayesian approach is utilized to combine the data from the two models to get a more exact appraise of BC concentrations[23]. The paper presents a recurrent air quality indicator based on meteorology- and pollution-related factors. The indicator employments a repetitive neural arrange (RNN) to memorize the worldly conditions between discuss quality and meteorological factors. The indicator was assessed on information from Beijing, China. The comes about appeared that the indicator can precisely anticipate discuss quality up to 24 hours in advance[24].

3. Requirements:

Hardware-

- Node MCU : NodeMCU is an open-source development board based on ESP8266 Wi-Fi module, designed to provide an easy way to connect IoT devices to the internet.
- MQ135 : It is a dynamic gas sensor which can detect various types of gases. It is commonly used in air quality monitoring systems, also to detect gas leaks. The sensor has a broad range of detection capabilities, gives quick response as well as is highly sensitive.

Software-

- Arduino IDE -

Arduino IDE is an open-source computer program utilized for composing and uploading code to microcontroller sheets like NodeMCU. It was utilized in this extend for coding the NodeMCU to examined and handle information from the MQ135 sensor, as well as for calibrating and testing the sensor.

- C++ Language -

C++ is the programming language used in the Arduino IDE to write code for the microcontroller. It is a high-level language that is easy to learn and widely used in embedded systems programming.

- Thing Speak -

ThingSpeak is an IoT analytics platform that allows users to collect, store, and analyse data from IoT devices. In this project, ThingSpeak was used to store the air quality data obtained from the MQ135 sensor, and to display the data in real-time using customizable graphs and charts. The data was also made accessible through a publicly accessible URL.

4. Methodology/Experimental

The MQ135 gas sensor module is a semiconductor-based sensor that can detect various harmful gases in the air, such as carbon dioxide, ammonia, and nitrogen oxides. It works on the principle of the change in resistance of the sensor with the change in concentration of the gases in the air. The sensor produces an analog voltage signal that can be read by a microcontroller, which can then convert the signal into PPM values using calibration data. The PPM values can be used to estimate the level of air pollution and take necessary actions to control it.

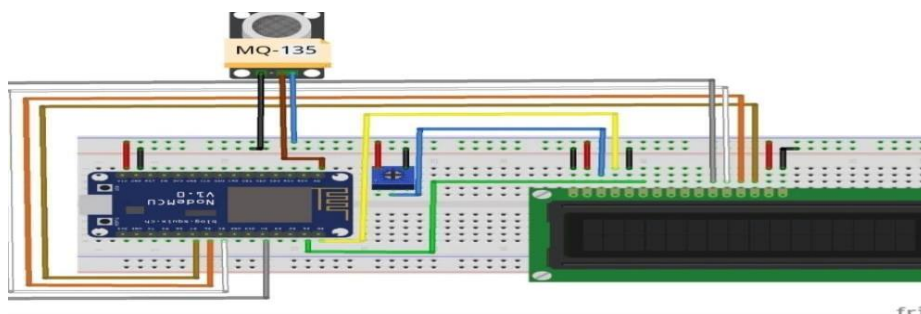


Fig. 1: NodeMCU board with the MQ135 gas sensor

Once the NodeMCU board reads the PPM values from the MQ135 gas sensor, it establishes a Wi-Fi connection with the ThingSpeak server using the Wi-Fi credentials. Then, using an API key provided by ThingSpeak, the NodeMCU sends the PPM data to the correspol field , the lcd screen will display two outputs good air and bad air which will help us to know the quality of air and the buzzer will ring when bad air detected.

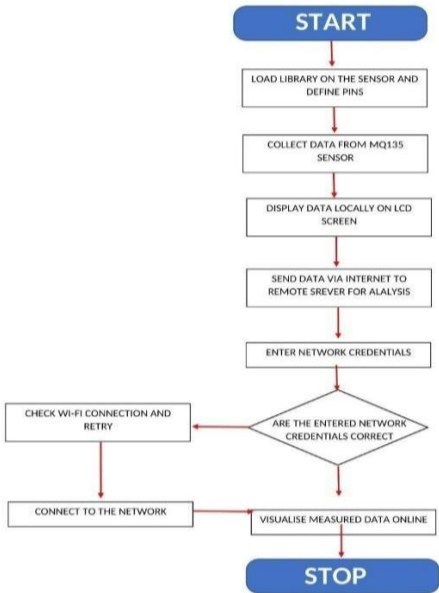


Figure 2. Flowchart

The ThingSpeak server receives the data and plots it on a real-time graph, which can be accessed via the ThingSpeak website or mobile application . This allows users to monitor the air pollution levels in their area and take necessary measures to improve air quality. In the above flow chart all the steps are given about the project will work in short from getting input from sensor MQ135 to analyzing the air and getting a output from sensor on things speak in format of graph and getting two outputs good air or bad air and ringing of buzzer when bad quality air is detected.

5. Results

After assembly, the air pollution meter device was left on for the period of 19 hours, to preheat the MQ135 gas sensor, which is essential to get the ‘activate’ the sensor so that it can be used for gas detection purposes.



Fig. 3 The PPM value of air quality detected in normal room conditions is around 150- 200ppm. PPM in an open, airy room.

The MQ135 gas sensor can detect smoke, CO₂, Benzene, Ammonia, Sulphur Dioxide and other harmful gases as shown in Figure 3. In this following graph the sensor detected 4 gases and uploaded the data on things speak this graph explain the quality of air so in this graph normal room condition is detected as room condition is around 150-200ppm

Test cases:

1. The air pollution meter was tested for smoke, with which it reacted accordingly-

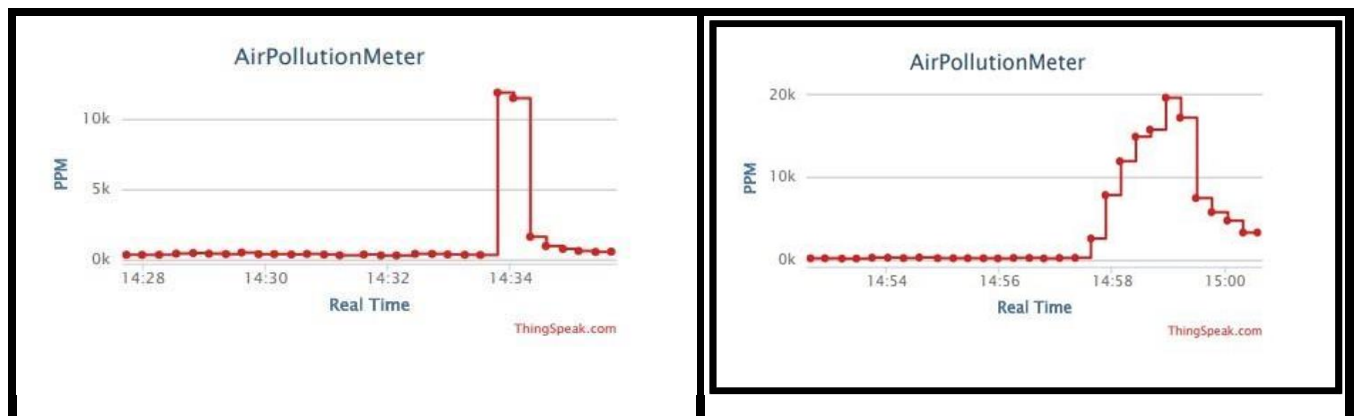


Fig.4 On introduction of benzene, the sensor returns highest of 19579 ppm.

Fig 4 On detection of smoke, the sensor returns PPM values reach highest of 11903 ppm. In this following graph the ppm value is highest means many parts of different gases are detected in the air so in further process we will know the gases and will get a output about the air is good or bad.

The pollution meter was tested with benzene, with which it reacted accordingly-

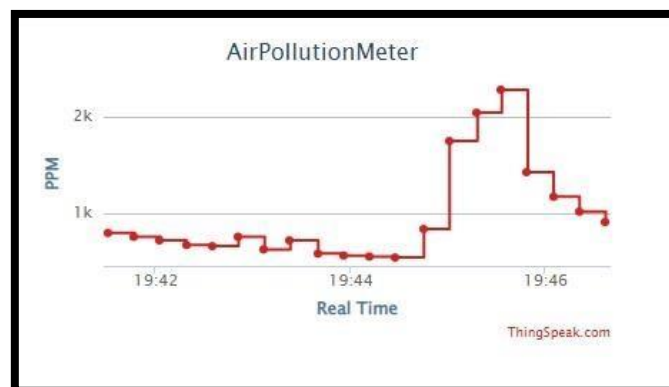


Fig. 6 On introduction of carbon dioxide, the sensor returns the highest 2272 ppm value.

In above graph carbon dioxide is detected and it has reach the value of 2272 ppm which is highest till know so as per boundaries we have made for air detection we will get the output of bad air or good air

Mathematical Analysis of Proposed Model –

The concentration of toxins within the discuss is measured in parts per million (PPM).

Conversion factors include the following:

$$PPM = A \times \frac{R_s^B}{R_0}$$

- PPM is the concentration of the gas in parts per million (ppm)
- R_s is the resistance of the sensor in ohms when exposed to the gas
- R_0 is the resistance of the sensor in ohms in clean air
- A and B are constants that are specific to the gas being measured

$$1 \text{ ppm} = 1.145 \text{ mg/m}^3$$

$$1 \text{ mg/m}^3 = 0.873 \text{ ppm}$$

$$1\% = 1/100$$

$$1 \text{ ppm} = 1/1000000$$

$$1 \text{ ppm} = 0.0001$$

Table 1 shows PPM to percentage conversion.

Parts Per Million (PPM)	Percent (%)
0	0
5	0.005
50	0.005
500	0.05
1000	0.1

```

23
24  /// The load resistance on the board
25  #define RLOAD 10.0
26  /// Calibration resistance at atmospheric CO2 level
27  #define RZERO 76.63
28  /// Parameters for calculating ppm of CO2 from sensor resistance
29  #define PARA 116.6020682
30  #define PARB 2.769034857
31
32  /// Parameters to model temperature and humidity dependence
33  #define CORA 0.00035
34  #define CORB 0.02718
35  #define CORC 1.39538
36  #define CORD 0.0018
37
38  /// Atmospheric CO2 level for calibration purposes
39  #define ATMOCO2 397.13
40

```

Atmospheric CO2 value for calibration purpose set at – 397.13 ppm^[8].

6. Conclusions

In conclusion, the Air Pollution Meter using MQ135 gas sensor and NodeMCU ESP8266 presented an effective solution for monitoring air pollution levels in real-time. The MQ135 gas sensor provided accurate readings of air quality, while the NodeMCU ESP8266 was able to process and transmit this data to the ThingSpeak server for storage and visualization.

Through the use of the Arduino IDE and C++ programming language, the system was able to be calibrated and tested to ensure accurate and reliable results. Overall, this project demonstrated the potential for low-cost and accessible air pollution monitoring systems that could help to address the issue of air pollution in our communities.

7. Acknowledgment

We would like to thank the learned faculty of VIT, Pune for their insightful guidance and support during the research process. We would also like to extend our gratitude to our seniors particularly Mr. Kaushal Sadavarte for advising as to how we should proceed with our project and what improvements could be made.

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