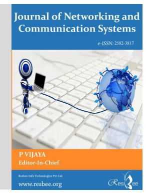
Vol.7 No.1 Jan 2024

Journal of Networking and Communication Systems

Received 2 December, Revised 15 December, Accepted 27 January



IoT-Based Air Quality Monitoring and Notification System

Md Ataullah Bhuiyan
Department of Computer Science and Engineering
City University, Bangladesh

Md SazzadHossen
Department of Computer Science And Engineering
City University, Bangladesh

Mahir Labib Hossain
Department of Electrical and Electronics Engineering
Ahsanullah University Science and Technology

Abstract: All recent active scientific and technological developments have focused on environmental issues considering theair quality system, high lighting the reality facing Bangladesh's serious health threats. A recent report lists morethan a dozen towns in Bangladesh in High. The Bangladesh Quality Index (AQI) was quickly rolled out to major citiesacross the country, including the capital Dhaka, to measureair pollution levels and help people identify bad Air Day. This paper develops the Internet of Things (IoT) that enable sportable air quality in nature monitoring systems analyzing environmental data in real-time ensuring CO, CO2, H2, CH4, NH3, alcohol, benzene, acetone, hexane, toluene, smoke, and flammable gas concentrations and particle matter level. The system can measure local air pollution, generate analytical data, and notify everyone through the system`s built-in device. An analysis wasperformed to follow up after implementation and assess the natural factors and the area of the arrangement. Based on the experiments, Preliminary results on the functioning of the monitoring system show a high level of acceptance by potential users.

Keywords: Node MCUESP8266UNO; Smartmonitoring; Gassensor; Soundsensor; Data Measure System; and Web Application.

Nomenclature

Abbreviation	Expansion
IOT	Internet of Things
AQI	Air Quality Index
PPM	Parts Per Million
WSN	Wireless Sensor Networks
QoS	Quality of Service

1. Introduction

IoT-based air quality monitoring and warning systems are systems powered by the IoT [1]. Technology that monitors real-time airquality and notifies users of changes in air quality System [2]. It consists of multiple sensors placed at different locations to detect air pollutants such as carbon, Carbon monoxide, Nitrogen oxides, Sulphur dioxide, and particulate matter. The AQI is calculated and backed by resource-consuming air pollutants such as CO and NO2 compounds. The AQI ranges represent the most detailed measurements of a specific carcass in the air at a specific point in time. It collectsgases/compounds in the air and continuously transmits data. This allows the authorities to monitor and take action on air pollution in different regions of Bangladesh [3] [4]. This is the unit of mass of matter perbillion units of total mass. PPM is a similarly conservative unitforme assuring pollutant concentrations.

When the Air quality drops to a certain level, the gases cause harm to humans, animals, plants, and all living beings on the earth. The harm causes health issues to worst cases deaths. This problem is especially important in high-altitude populations with a low concentration of oxygen [5]. Concerned about this issue researchers are looking for various solutions to estimate pollution levels in the surroundings through various sensors, image perception, using machine learning algorithms and chemical processes to determine the pollution levels in the rural and urban areas. The majority of deaths from air pollution are caused by PM 2.5 particles [6]. These are microscopic particles smaller than2.5 μmin in diameter that are invisible to the naked eye. These cannot be filtered through the nose and are easily inhaled into the lungs, causing heart attacks, strokes, and other respiratory illnesses. PM10 is particulate matter with a diameter of 10 micronsorless, and PM 2.5isparticulatematterwithadiameter of 2.5 microns or less. PM 2.5 is commonly described as fine dust. For comparison, human hair is about 100 microns thick, so about 40 micro particles can be placed across

https://doi.org/10.46253/jnacs.v7i1.a3

the width PM 2.5 is the recognized global standard for measuring airquality [6].

To better understand air pollution and to develop effective measures to reduce the hazards. This project created an IoT-based air pollution detection and monitoring system. The system monitors air quality via a web server with an ESP8266 Wi-Fi device and triggers alarms if necessary. Air quality is monitored through the display in PPM on the LCD and web pages. Sensors are connected via the Internet to a central server or cloud-based platform where the data resides. Users can access data and receive air quality notifications through their mobile phone application or its n web-based on inter face (Blynk).

The projects use many sensors that periodically send back data to reflect the latest state with the accuracy and precision of the measurements. Almost all air quality sensors used around the world face the problem of accuracy in the result due to various conditions. The focus of this project is

1. To take these measurements and correct them using high-precision sensors.
2. Developing algorithms for environmental measurement of air variables by the reviewed systems.
3. To analyze the published papers from the year 2014 to 2019.

The results showed that the proposed system can successfully show each parameter of the air quality on the system to make suggestions about the overall air quality level and sent notification as required. The remainder of this document is organized as follows: Section 2 presents the literature review. Section 3 describes the proposed system and the development methodology. Section 4 explains the setup of the project, hardware, and software requirements. Section 5 analyses the results that are obtained during the testing of the data. Section 6 discusses the main outcomes obtained with the proposal presented in this paper. Finally, Section 7 mentions the advantages and disadvantages of the proposed method, and Section 8 outlines the conclusions and future work.

2. Literature Review

The theoretical back ground for IoT–based air quality monitoring and notification systems in areas of environmental science, WSN, and IoT technology. Air pollution is a serious environmental problem that affects public health and the environment. Air Quality monitoring is essential to identify sources of contamination, assess heal thrisks, and take necessary measures to reduce air pollution.

WSN saree merging as a promising technology for environment monitoring including airquality monitoring. WSN scan communicate with each other from a network and send data to acentral server for further analysis. Enables real-time data collection, analysis, and communication. IoT-based air quality monitor. The system can use a combination of WSN and IoT technology to collect real-time air quality data. It uses several sensors that send data to a central server. In summary, IoT-based airquality monitoring and this alarm system combine concepts from environmental science, WSN, and IoT. Technologies that provide comprehensive solutions to monitor airquality and improve public health and security.

Existing Work01

Title: IOT-Based airquality monitoring system using mq135 and mq 7with Machine learning analysis. [9]

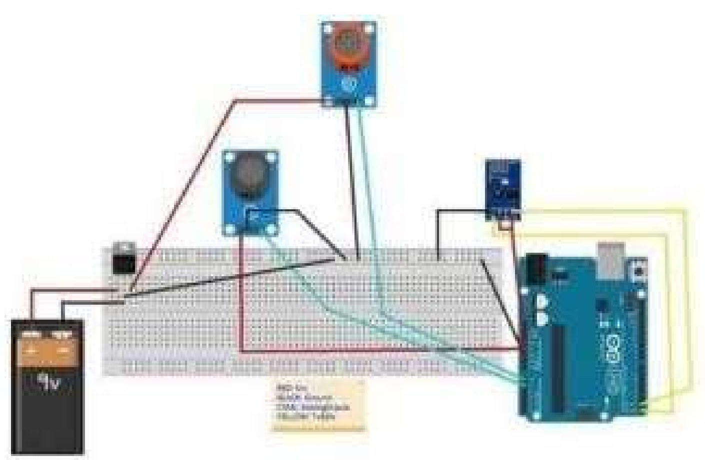


Fig. 1. *Existing work 01*

Measuring Air Quality is an important element for bringing awareness to take care of future generations and for a heal thier life. Based on this, the Government of India has already taken certain measures to ban single-stroke and two-stroke engine-based motorcycles which emit high pollution. They implement a system using IoT platforms like Thing Speak or Cayenne to bring awareness to every individual about the harm we are doing to our environment. They used the easiest platform like Thing Speak and set the dashboard to the public such that everyone can come to know the Air Quality at the location where the system is installed.

Key Feature:

- IoT
- MQ135, MQ7
- Machine Learning

Existing Work02

Title: Designing an IoT–based airquality monitoring system [8]

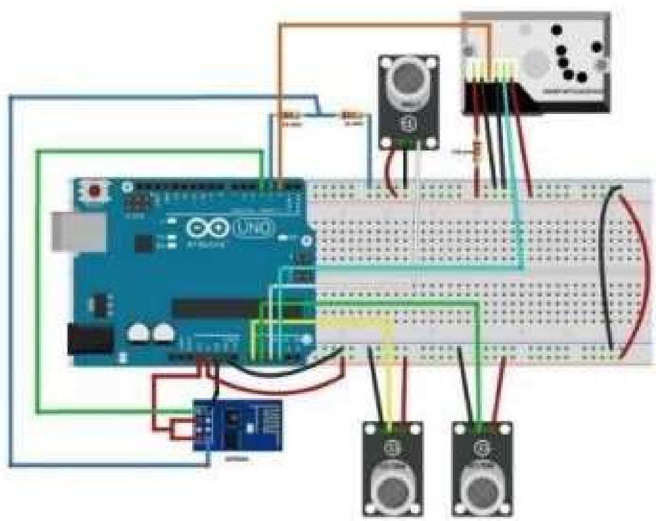


Fig. 2. *Existing work 02*

The airquality of a region has a great impaction the conditions of its inhabitants. Quality can affect human, animal, and plant health. Therefore, it is necessary to regularly Monitor the airquality status in the area. This research was an IoT-based airquality monitoring system. Developed to determine the state of airquality with in a region. The system monitors the usage of Sensors that measure the level sofvarious substances in the air, such as O_3, SO_2, CO, and particles. Read sensor data using the Node MCUESP8266 microcontroller. The data was then sent to the Thing Speak cloud system utilizes her WIFI module on Node MCUESP8266 by accessing API. It is provided by the cloud service" Thing Speak". Monitoring results can be checked on the web A page provided by the cloud service Thing Speak.

Key Feature:

- NodeMCUESP8266UNO
- 4 types of sensors to measure several types that are in the air, namely MQ-7, MQ1-131, MQ-135, and Pm10.
- Smart monitoring

Existing Work03

Title: IoT-Based Low-Cost Air Quality Monitoring System with Power Consumption Optimization [7]

Fig. 3. *Existing work03*

This work attempted to solve topology design issues, evaluating QoS levels against accuracy, detection through put, and power consumption optimization. Business operational, IoT-based airquality monitoring systems have been deployed indoors and outdoors locations to measure airquality parameters such as PM10, PM2.5, carbon monoxide, Temperature, and humidity. The recommendation system was also tested at different service quality levels on indoor and outdoor sites. The experiments conducted also recorded the accuracy in terms of sending messages reliably according to the protocol used. [7]

Key Feature

- Airquality monitoring
- Message Queue Telemetry Transport protocol, smart city.
- Node MCUESP8266

Existing Work04

Title: IoT-based air quality monitoring systems for smart cities: A systematic mapping study [10]

Fig. 4. *Existing work04*

Technology has become a very useful tool in pollution monitoring and mitigation of its impact. In particular, there were different proposals using the IoT model. In this article, They developed a systematic apping study defined using a five-step method for study identification and analysis status of IoT-based airpollution monitoring systems for smart cities. They analyzed and compared these proposals according to different parameters defined in mapping and marked up some challenges for the implementation of airquality monitoring systems in the context of smart cities.

Key Feature:

- Airquality monitoring Iot
- Smart cities.
- Systematic mapping study

Existing Work05

Title: Building an indoor airquality monitoring system based on the architecture of the IoT [11]

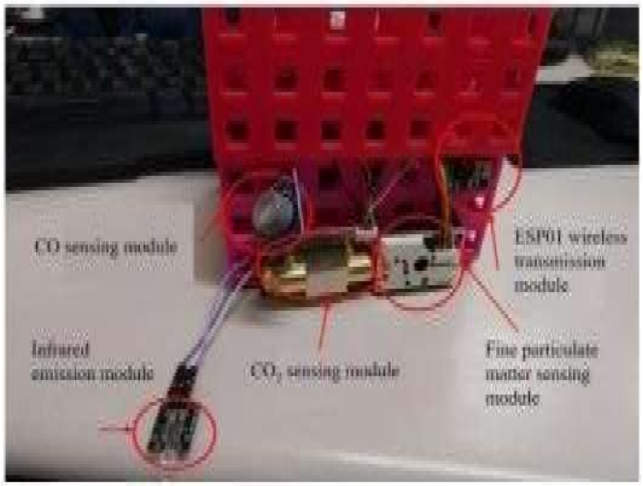


Fig. 5.*Existing work05*

With rapidly changing technology, people have more and more requirements for thermal comfort regarding indoor temperature, humidity, and wind speed, and pay more attention to airquality. Based on the architecture of the IoT smart home, this study constructed an indoor air quality monitoring system to explore how people can live in an environment with good airquality. The common points of the two dices are combined, and then, based on the data of the Environmental Protection Administration, indoor and outdoor environment parameters are analyzed and controllable environment variables are simulated to analyze their effects on air quality. This study designed effective load control using fuzzy control and developed a fuzzy rule base for the simulation of the environment variables. Decision logic was used to replace the threshold control of indoor airquality in the past and a comfortable air quality monitoring system was designed by combining the Node MCUESP8266 Uno development board and ESP8266Wi-Fi wireless transmission modules.

Key Feature:

- Airquality monitoring, IoT.
- Fuzzy control, Wireless transmission
- Node MCUESP8266

2.1 Review

In each existing project, they used various sensors to detect different gases that are present in the atmosphere. They are

1. **MQ-3 Gas Sensor:** The MQ-3 gas sensor uses a small heater inside the sensor to heat a semiconductor material made oft in oxide (SnO2). When alcohol gas is present in the air, it reacts with the SnO2 material and reduces the resistance of the material. This change in resistance is measured and processed by a sensor circuit and can be used to determine the concentration of alcohol in the air.
2. **MQ-4 Gas Sensor:** The MQ-3 gas sensor uses a small heater inside the sensor to heat a semiconductor material made of tin oxide (SnO2). This makes the material more conductive and more sensitive to environmental changes.
3. **MQ-135 Gas Sensor:** The MQ-135 gas sensor is widely used in air quality monitoring systems, air purifiers, and other applications where air pollutant monitoring is required. However, it is important to note that sensor accuracy and sensitivity can be affected by various factors such as temperature, humidity, and other environmental conditions. Therefore, it is important to properly calibrate and test the sensor before relying on accurate gas detection.
4. **MQ-7 gas sensor:** The MQ-7 gas sensor is widely used in carbon monoxide detectors, flue gas analyzers, and other applications requiring carbon monoxide monitoring. However, it is important to note that the accuracy and sensitivity of the sensor can be affected by various factors such as temperature, humidity, and other environmental conditions. Therefore, it is important to calibrate and test the sensor properly before relying on accurate gas detection.
5. **MQ-8 Gas Sensor:** MQ-8 gas sensors are widely used in hydrogen gas leak detectors, Hydrogen fuel cell monitoring systems, and other applications where hydrogen monitoring is required.

However, it is important to note that sensor accuracy and sensitivity can be affected by various factors such as temperature, humidity, and other environmental conditions. Therefore, it is important to properly calibrate and test the sensor before relying on accurate gas detection.

6. **MQ-9 Gas Sensor:** MQ-9 gas sensors are widely used in gas leak detectors, automotive emission testers, and other applications where monitoring of carbon monoxide or combustible gases is required. However, it is important to note that sensor accuracy and sensitivity can be affected by various factors such as temperature, humidity, and other environmental conditions. Therefore, it is important to properly calibrate and test the sensor before relying on accurate gas detection.

These sensors are used in the existing projects, Table 1 portrays the project features of the five existing projects. Each method has certain benefits and shortcomings that were explained in detail.

Table 1:*Review Based on Existing Methods*

Existing project	Project features									
	Node MCU ESP8266	MQ3 Gas sensor	MQ4 Gas sensor	MQ135 Gas sensor	MQ7 Gas sensor	MQ8 Gas sensor	MQ9 Gas sensor	Alarm Sensor	DHT11 Sensor	Budget	Mobile App
Existing Work-1 [9]	No	No	No	Yes	Yes	No	No	No	No	High	No
Existing Work-2 [8]	No	Yes	No	Yes	Yes	No	No	No	No	High	No
Existing Work-3 [7]	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	High	Yes
Existing Work-4 [10]	Yes	Yes	No	Yes	No	No	No	No	Yes	High	Yes
Existing Work-5 [11]	Yes	Yes	No	Yes	No	Yes	No	No	Yes	High	Yes
Proposed System	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Low	Yes

2.2Research Gap

The above studies have been deployed to monitor the quality of air [7-11] using various technologies and sensors. Each project used different sensors to detect the various pollutants in the air. However, the sensors are limited in each experiment. This leads to the non-detection of certain types of air pollutants in air. Based on previous studies, it was concluded that previous research had not studied all the combined pollutants such as CO, CO2, H2, CH4, NH3, alcohol, benzene, acetone, hexane, toluene, smoke, and flammable gas concentrations and particle matter level using an IoT-based website as an interface for displaying the results of the air quality measurement system along with the notification system. It is important to measure all types of pollutants and to send notifications to users. Therefore, in this research, we proposed an air quality monitoring system based on IoT that can measure various pollutants in certain locations and display the measurement results on a web page.

3. Methodology

3.1working Strategy

An IoT-based air quality monitoring and notification system collects data from various sensors installed in various locations, processes the data, and provides real-time airquality information to users. Below is a step-by-step overview of how the system works:

- Initially, Instal sensors at different locations to collect airquality information. These sensors detect temperature, humidity, CO2, PM2. 5, and PM10levels.
- Wireless communication technologies such as Wi-Fi and Bluetooth are used by the sensors to collect data and transmit it to a central hub.
- The collected data from the sensor are processed immediately to determine indoor airquality areas. The AQI is calculated from the concentrations of different pollutants.
- A notification system then alerts the users regarding the air quality in the area. Notice can be delivered as push notifications or mobile app notifications.
- Processed data is also displayed on the web-based application dashboard to provide a real-time visual representation of airquality. Users can access this dashboard to check the airquality in there area.

- The system also stores historical data that can be used to analyze long-term trends and patterns in airquality.

In summary, IoT-based air quality monitoring and warning systems work by collecting, processing, and analyzing data from sensors to provide users with real-time alerts on ambient airquality. The system also provides a visual representation of air quality and stores historical data for further analysis.

3.2proposed System Architecture

In this work, we propose a cluster of air quality monitoring gas sensors used to measure the concentration of air pollutants in the air. Gassensorsare used to collect gas concentration measurements. This sensor data is captured and sent to an Arduino Nano for IoT-based data collection. The microcontroller collects and processes the data for transmission. With the help of internet connectivity, the process data is sent to the cloud environment. The data are then analyzed and the results are displayed on the screen as an alert or notification. To provide a stable and appropriate power supply for the sensor, microcontroller, and communicating devices a transformer was connected to draw the power supply and to adjust the voltage supply. Then the current was converted to a rectifier and regulator to ensure the stability of voltage output. The architecture was pictographically explained in Fig. 6.

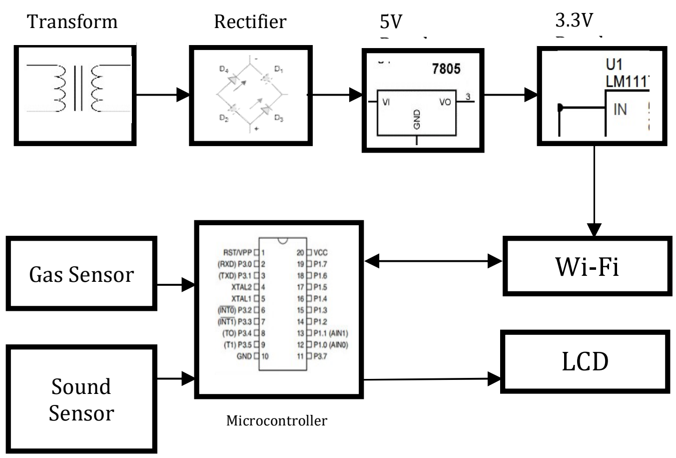


Fig. 6. *Proposed System Architecture*

3.3 The System Design

The system design involves the collaboration of hardware, software, data, and user interface designers to ensure the effective function of the system. Initially determine the parameters of the monitoring and set the pre-written codes or functions in the software as libraries and declare the variables. Then the sensor will detect the air and generate data through various methods like changing the resistance, voltage, or capacitance based on the gas concentration. The obtained data was then converted to readable form using an analog-to-digital converter or digital communication protocols based on the sensor type. The serial monitor is a tool used for viewing data sent from the microcontroller to a computer via the USB port. The code reads an analog sensor connected to pin A0, converts the analog value to voltage, and displays both the raw sensor value and the corresponding voltage in the Serial Monitor. When the code is uploaded to an Arduino board and the Serial Monitor is opened in the Arduino IDE, it will continuously display the sensor data in the specified format. This approach demonstrates the analog sensor data can be read by a microcontroller, processed, and displayed in the Serial Monitor for local observation and debugging purposes. After that, the obtained data was sent over the internet to an IoT platform's API endpoint. The system includes security measures to authenticate and authorize access to the IoT platform's API. This involves the use of credentials like API keys. It verifies that the sender to access the data.

The data are stored securely in the designated channel or database. Finally, Visualization tools provided by the platform allow users to view real-time or historical data in the form of graphs, charts, or tables. The flow process of the system design is explained in Fig. 7.

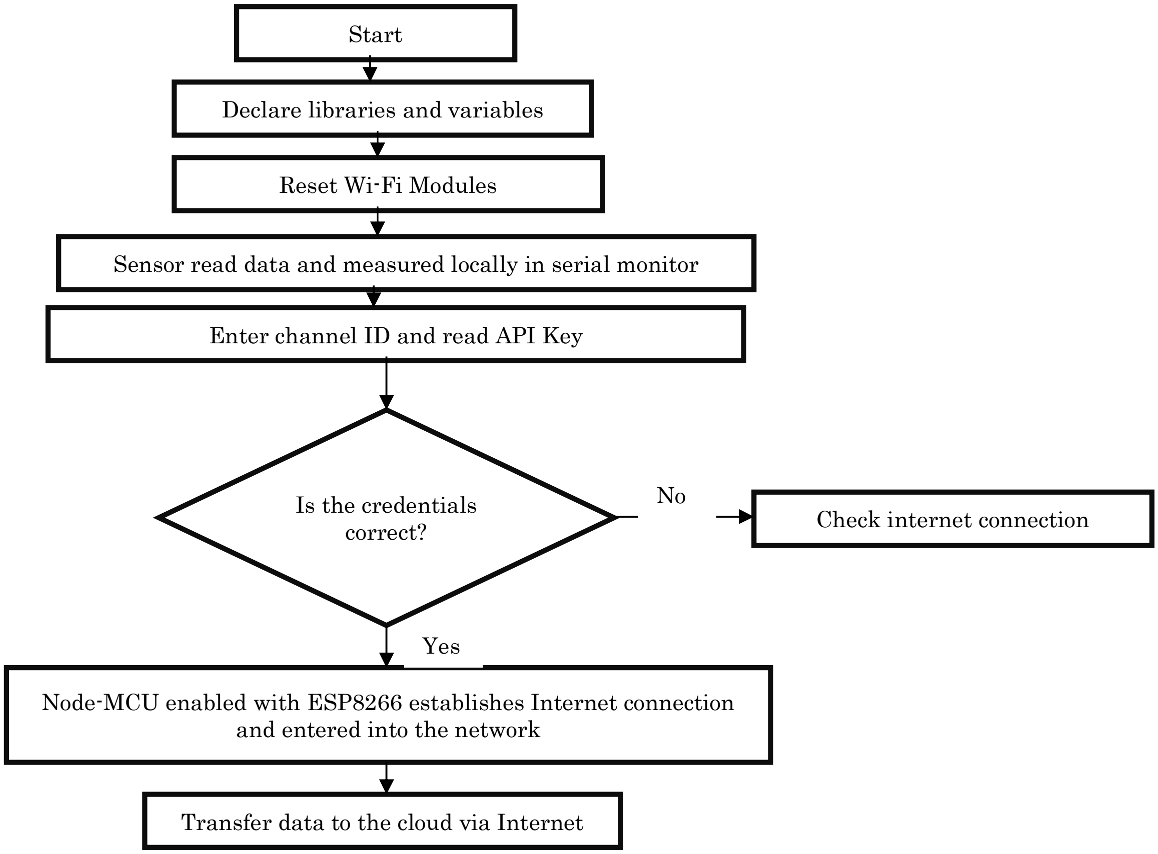


Fig 7. *System Design*

3.4The Circuit Diagram

The block diagram provides a complete overview of the components and their functions. The gas sensor detects various air quality parameters and sends the collected data to the microcontrollers where initial processing and data are prepared for transmission. The wi fi devices help to establish connectivity for data transmission. Cloud Platform stores data, performs analysis, and triggers alerts through the Notification System (buzzer) when predefined thresholds are exceeded. The Notification System alerts users through various channels through LCD. Fig. 8 provides a detailed explanation of the circuit diagram.

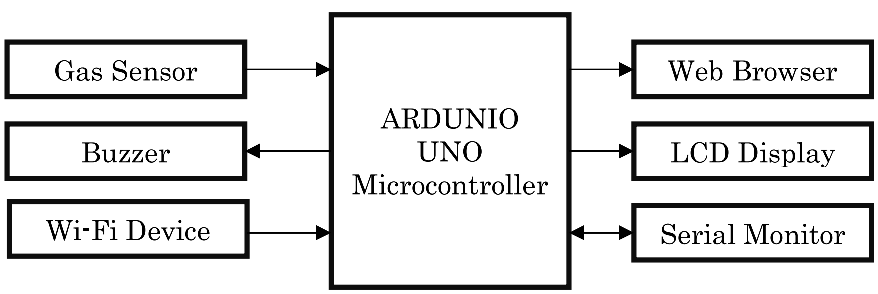


Fig. 8. *Circuit Diagram*

3.5working Process

A gas sensor and a Wi Fi device are connected to an Arduino board. Liquid crystal also connects to an Arduino board and Connect ESP8266 to Arduino Nano3.3V, when connected directly to the Arduino. It communicates with the Arduino Nano. Connect the TX pin of the ESP8266 to pin 8 of the Arduino and the RX pin of the ESP 8266 to pin 9 of the Arduino nano. Next, connect the MQ135, MQ2, MQ3, MQ4, MQ7, MQ9 and DHT11 sensor to the Arduino Nano. Connect the VCC and ground pins of the sensor to 5V and ground on the Arduino, and connect the analog pin of the sensor to A0 on the Arduino. Connect a buzzer to pin 7 of the Arduino and it will start beeping when the condition becomes true. Finally, connect the LCD to the Arduino. LCD connections are as follows: Connect pin VCC to 5V on the Arduino. Connect the GND pin to the GND on the Arduino. Connect pin D6 to pin 3 on the Arduino. Connect pin D7 to pin 2 of the Arduino Nano it is explained in Fig. 9.

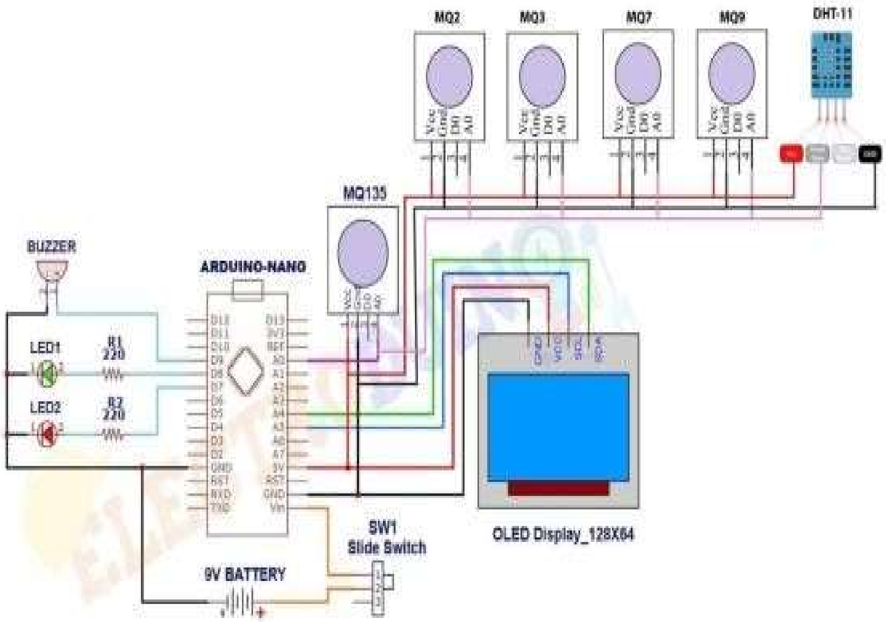


Fig. 9.*Block diagram for the proposed model of the system*

4. Setup the Hard Ware of this Project

ESP8266 Wi-Fi device is connected to the Arduino VCC and the CH_EN is connected to the 3.3V pin of Arduino. The TX pin is connected to pin 8 of Arduino. The RX pin is connected to pin 9 of Arduino. GND is connected to the pin GND of Arduino and connects the MQ135, MQ2, MQ3, MQ4,MQ7, MQ9, and DHT11 sensors to the Arduino Nano and Speaker is connected with the Arduino. The VCC pin is connected to pin 5v of the Arduino. The GND pin is connected to the GND of the Arduino. AO is connected to the A0 of the Arduino. The pin of the speaker is connected to the GND & pin 7 of the Arduino. LCD is connected to Arduino. VCC & GND pin is connected to the 5 V & GND of the Arduino. RS pin is connected to the Arduino pin 12; the E pin is connected to the Arduino pin11. D4, D5, D6, & D7 pins are connected to the Arduino pins 05, 04, 03, & 02. Fig. 10 shows the setup of the hardware connection.

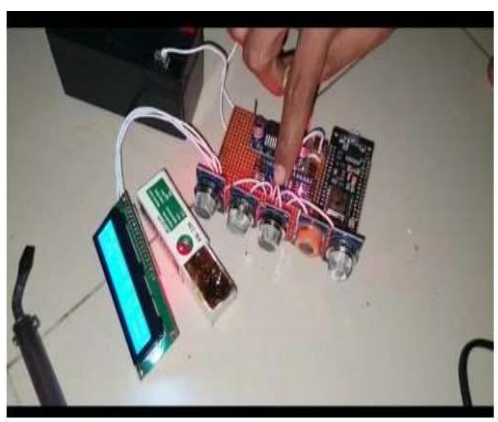


Fig. 10: Setup of hardware system

4.1Setup the Mobile Application of this Project

The Blynk application was to implement an IoT-based air quality monitoring and notification system. Blynk is a popular platform for building IoT applications that enable remote control and monitoring of connected devices. The steps that are used to create an IoT-based air quality monitoring and notification system using Blynk.

4.2 Hard Ware Components

- Air quality sensor.
- Node MCU or similar micro controller board
- Bread board and jumper wires
- USB cable for programming and power supply

4.3 Software Components

- Arduino IDE for programming microcontrollers
- Blynk app for monitoring airquality readings on mobile devices.

4.4 Procedure for Connecting The Mobile Application

Connect the air quality sensor to the Node MCU board and setup the hardware components. Create a new project in the Blynk app and add a value display widget. Configure the widget to display his AQI value received from the Node MCU board. Add a notification widget to your Blynk app and set the AQI threshold. A notification widget sends a notification to the user's mobile device when the AQI value exceeds the threshold. Upload the program to her Node MCU board and run her Blynk apponher mobile device. The app displays the current AQI value and sends a notification when the value crosses the threshold. Fig. 11 shows the result of each component in the LCD screen.

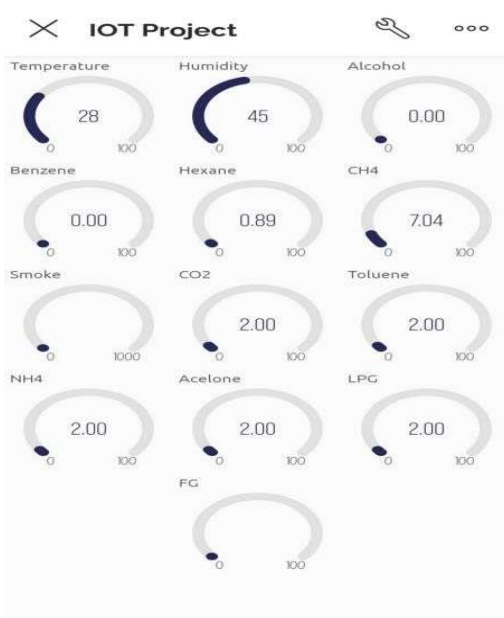


Fig. 11. *Mobile Application System display*

5. Testing Report

The testing was conducted in the capital Dhaka, Bangladesh. The test was carried out throughout the week from Saturday to Friday from MQ3, MQ4, MQ135, MQ7, MQ8, and MQ9 gas sensors. The test scheduled report is explained in Table 2.

Table 2: *Testing report of gas sensors*

Gas Sensor	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
MQ 3	✔	✔	✔	✔	✔	✔	✔
MQ 4	✔	✔	✔	✔	✔	✔	✔
MQ 135	✔	✔	✔	✔	✔	✔	✔
MQ 7	✔	✔	✔	✔	✔	✔	✔
MQ 8	✔	✔	✔	✔	✔	✔	✔
MQ 9	✔	✔	✔	✔	✔	✔	✔

Source: Own report

The data was collected hourly to analyze the air quality measurements. The sensor measures the average concentration of pollutants (PM2.5) in the air over an hour and converts this into an AQI value and the value will be displayed in the web-based monitoring application. The AQI value is calculated between 0 and 500 on a numerical scale, to identify the quality of the air as good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy, and hazardous.

The recognized acceptable standard for AQI is up to 100[12], When the air quality is very low then the air is good and if the pollution level is less than 100 then it is moderate and acceptable. When air quality degrades to an AQI above 100 then sensitive groups of people may experience adverse health effects. When the value is above 150 AQI then it is considered unhealthy and people have a high risk of adverse health issues and the severity increases when the AQI excess of 200 and above represents extremely unhealthy.

With respect to the application layer, we postured two investigate questions (RQ1 and RQ2), related to the checked natural factors and the area of the arrangement. Fig. 12 appears the utilized factors within the analyzed checking frameworks in this ponder. Particulate matter (PM) (2.5 µm and 10 µm), nitrogen oxides (NOx), carbon monoxide (CO), ozone (O3), and carbon dioxide (CO2) are the foremost commonly measured toxins. Temperature and humidity are frequently related to sensors calibration, which can be the reason for their visit utilization. Alkali, hydrocarbons, sun powered radiation, and unstable natural compounds are valuable in other particular applications. Ordinarily, the choice of which variables to incorporate depends on the specific conditions of the city to be checked, i.e., the most discuss toxins show within the city zone. The benefit layer, which is dependable of giving administrations to "things" or applications, is between the arrange and the application layer. The usage of the benefit layer ordinarily includes cloud improvement. The frameworks analyzed in this consider portray basically the two to begin with layers of the IoT engineering (i.e., discernment and organize layers), which come about in a destitute portrayal of the benefit layer, hence not giving sufficient usage points of interest in this layer. Most of the handling is carried out on cloud stages, where fog/edge computing is still small investigated in this setting. We did not find anitty gritty portrayal of its execution, hence complicating to reply the investigate address RQ3 stated as, what are the most provided services to the applications. Fig. 12 Implemented Result From the result, we can obtain the various levels of temperature, humidity, CO, SO_2, and other pollutants that are present in the atmospheric air.

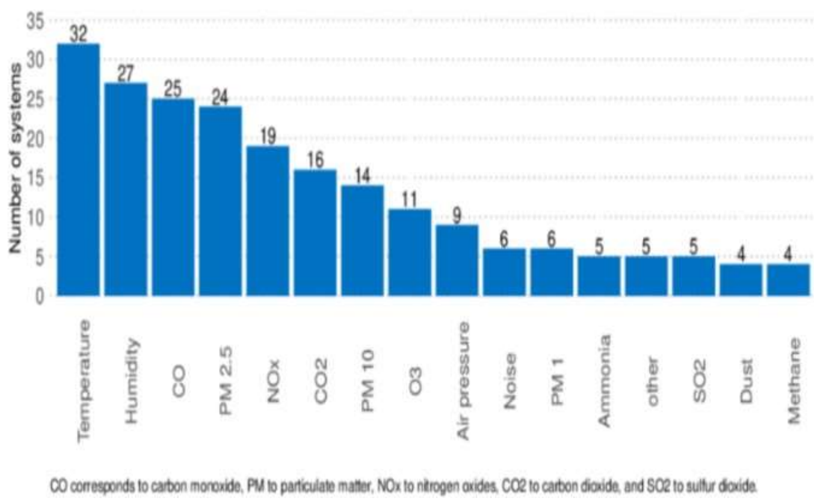


Fig. 12. *Histogram of environmental measured air variables by the reviewed systems*

In the Fig. 13, the left side of the image features a bar graph labeled "Number of papers" on the y-axis and years from 2014 to 2019 on the x-axis. The graph shows the number of papers published each year from 2014 to 2019.

In 2014, there were 2 papers published. In 2015, there were 7 papers published. In 2016, there were 9 papers published. In 2017, there were 19 papers published. In 2018, there were also 19 papers published. In 2019, there were 18 papers published.

The right side contains a pie chart with different colors representing various types of journals and conferences.

- Conference: Light blue slice representing 3.6%
- Q2 Journal: Purple slice representing 9.1%
- Q1 Journal: Dark blue slice representing 14.5%

- Q3 Journal: Green slice representing 18.2%
- Other journal: Grey slice representing 54.6%

Both graphs are clean and straightforward with distinct colors for easy interpretation.

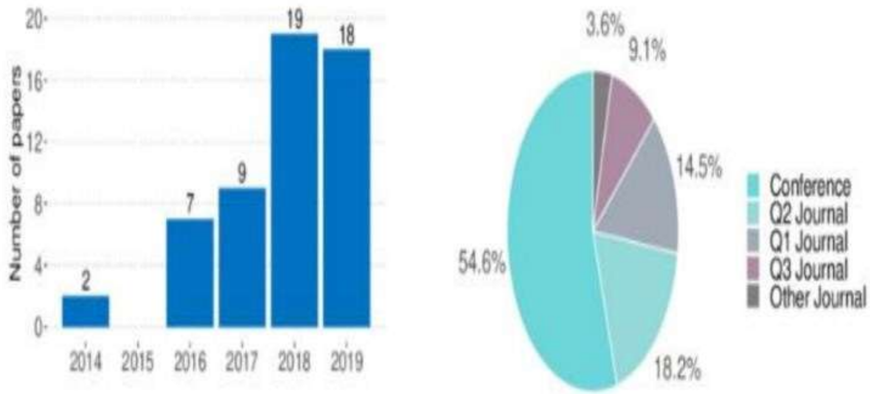


Fig .13. *Histogram & Pie Chart of the data Interpretation*

The various web application results are obtained during the measurement through various places. Fig 14a and 14b show insights into various pollutants in different locations.

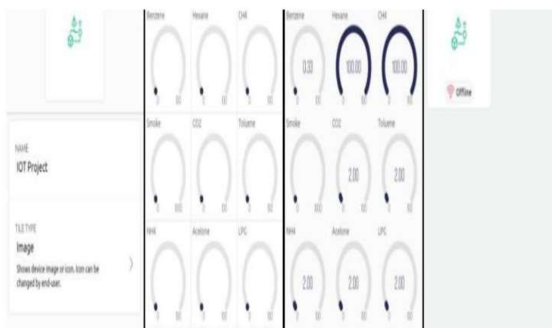


Fig14a. *Insights of air pollutants in atmospheric a*

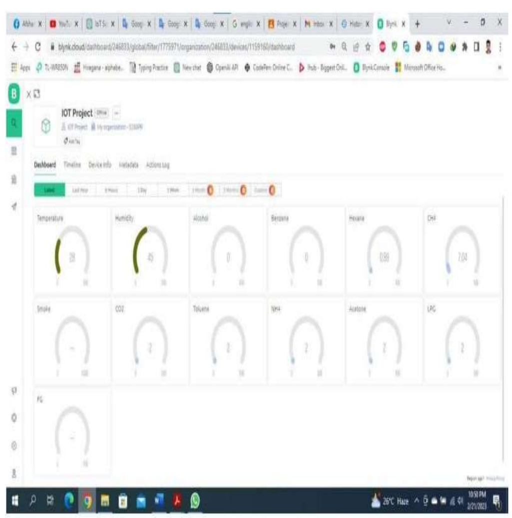


Fig. 14b. *Insights of air pollutants in atmospheric air*

6. Discussion

Dhaka city has a total area of 306 square kilometers. It is a megacity and has a population of 10.2 million residents as of 2022, and a population of over 22.4 million residents in the Dhaka Metropolitan Area [13]. The population growth is rapid with a rate of three percent per year primarily due to the mean of migration from the rural regions [14]. Historically, The city challenged poor air quality due to various factors like traffic congestion, industrial emissions, construction activities, and burning of biomass. During certain times of the year, like winter, when atmospheric conditions can contribute to the trapping of pollutants. High levels of particulate matter (PM2.5 and PM10), sulfur dioxide (SO2), nitrogen dioxide (NO2), and other pollutants have been reported to exceed safe limits set by health organizations such as the World Health Organization (WHO).

Dhaka faces significant traffic congestion, resulting in high emissions from vehicles. The exhaust fumes contribute to elevated levels of particulate matter (PM2.5 and PM10) in the air. The presence of numerous industries in and around Dhaka also contributes to air pollution. The textile industries, manufacturing industries, and small and large scale industries cause high pollution in Air, Water, and Soil. Factories and industrial units release various pollutants into the atmosphere. A high population leads to construction projects that generate dust and particulate matter.

Accuracy and precision: One of the most important aspects of an air quality monitoring system is the accuracy of the sensors and accuracy. Therefore, improving sensor accuracy and precision is essential to ensure Reliable and accurate at a collection.

Another important aspect fan airquality monitoring system is the reporting system. The system must be able to alert the user in realtime when the air quality drops below a certain threshold. Integration with other systems. Airquality monitoring systems need to be integrated with other systems to provide a better overall information solution. Integrate this system in to a smart home. The system can help triggeractions such as turning on the air purifier or closing the windows in the event of poor airquality.

7. Advantages and Disadvantages

Advantages

- Its user-friendly, web or mobile app will then have to be developed to display air quality data in an understand able format.
- Applications can able to display real-time data, historical trends, and forecasts, and provide personalized recommendations to help users improve air quality.
- The system is designed to send notifications to users when the airquality in there area is reaching unhealthy levels.
- IoT-based airquality monitoring and reporting systems have the potential to improve public health and reduce the negative impact of airpollution on the environment.
- By receiving real-time airquality data and alerts, individuals can take preventive action to protect themselves and reduce their exposure to harmful pollutants.

Disadvantage

- Regular calibration and maintenance of sensors are crucial to ensure accurate readings. Failure to do so can lead to drift in sensor accuracy over time.
- The process gathered vast amounts of data, raising concerns about data security and privacy.
- Limited coverage or incorrect placement of sensors in certain areas might lead to incomplete or biased data.

8. Conclusion

In summary, an IoT-based airquality monitoring and notification system is a promising solution to address the problem of increasing airpollution. Implementing an IoT-based air quality monitoring and notification system offers many benefits, including early warning of airpollution, improved health, and reduced medical costs. However, there are also some challenges to consider when implementing such systems, such as the cost of sensors and other hardware, the complexity of data analysis, and improvement in making airquality monitoring systems accessible and affordable for everyone. In addition, the user interface is easy to use and understand, making the system accessible to more people. Overall, IoT-based air quality monitoring and notification systems will bring more accurate, reliable, and accessible data to help people make better decisions to protect human health and the environment. There's potential for big improvements that could help

Interpretation and the need for ongoing maintenance and support. IoT-based airquality monitoring and notification systems show promise in improving airquality and protecting public health.

9. Future Work

An IoT-based air quality monitoring and reporting system is an important tool to tackle airpollution. Here are some potential areas of future work for IoT-based airquality monitoring and reporting systems:

- **Improved sensor technology**: The accuracy and reliability of the sensors used in airquality monitoring systems are essential.
- **Extend coverage**: Although air quality monitoring systems have been implemented in many cities, there are still areas that have not been covered. Future work may focus on ending the coverage of air quality monitoring systems in rural and remote areas.
- **Integration with other IoT devices**: IoT-based airquality monitoring systems can be integrated with other IoT devices, such as smart home appliances, to improve in door airquality.
- **Build predictive models**: By analyzing past airquality data, it is possible to develop predictive models that can predict future airquality.
- **Public education**: Air pollution is a complex issue that requires public awareness and understanding. Future work may focus on developing educational materials and campaigns to help individuals understand the health risks associated with poor air quality and their role in mitigating it.
- **Data analysis**: As air quality monitoring systems generate large amounts of data, future work may focus on developing algorithms and analytical tools to derive valuable insights from the data.

Overall, there is a lot of potential for future work in the field of IoT-based airquality monitoring and reporting systems. By continuing to improve technology and expand coverage, we can better understand and tackle airpollution.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

Reference

[1] N. Penchalaiah,V. R. K. Reddy, S. R. Mohan, D. P.K. Reddy and G. T. Yadav, "IoT-Based Air Quality Monitoring System with Server Notification," In International Conference on Communications and Cyber Physical Engineering 2018, Singapore: Springer Nature Singapore, pp. 1099-1108, Mar. 2023.

[2] T. Kumar and A. Doss, "AIRO: Development of an Intelligent IoT-based Air Quality Monitoring Solution for Urban Areas", Procedia Computer Science, Vol. 218, pp.262-273, 2023.

[3] Airqualityindex (AQI)andPM2.5airpollution in Bangladesh:https://www.iqair.com/bangladesh.

[4] R. R. Rahman and A. Kabir, "Spatiotemporal analysis and forecasting of air quality in the greater Dhaka region and assessment of a novel particulate matter filtration unit", Environmental Monitoring and Assessment, Vol. 195, no. 7, pp.824, 2023.

[5] S. Smidt, "Assessment of Air Pollution Stress on Forest Ecosystems by the Example of the Northern Tyrolean Limestone Alps",J. Plant Physiol. Vol. 148, pp. 287–295, 1996.

[6] M. S. Islam,S. Roy,T. R. Tusher, M. Rahman and R. C. Harris, "Assessment of Spatio-Temporal Variations in PM2. 5 and Associated Long-Range Air Mass Transport and Mortality in South Asia", Remote Sensing, Vol. 15, no. 20, pp.4975, 2023.

[7] V. Barot, V. Kapadia and S. Pandya, "QoS enabled IoT based low-cost air quality monitoring system with power consumption optimization", Cybernetics and Information Technologies, Vol. 20, no. 2, pp.122-140, 2020.

[8] T. H. Nasution, M. A. Muchtar and A. Simon, "Designing an IoT-based air quality monitoring system", In IOP conference series: materials science and engineering (Vol. 648, No. 1, pp. 012037). IOP Publishing, Vol. 648, No. 1, pp. 012037, Oct. 2019.

[9] K. B. K Sai, S. R. Subbareddy Sand A. K. Luhach, "IOT based air quality monitoring system using MQ135 and MQ7 with machine learning analysis", Scalable Computing: Practice and Experience, Vol. 20, no. 4, pp.599-606, 2019.

[10] D. Munera, J. Aguirreand N. G. Gomez, "IoT-based air quality monitoring systems for smart cities: A systematic mapping study", International Journal of Electrical and Computer Engineering, Vol. 11, no. 4, pp.3470, 2021.

[11] W. T. Sung and S. J. Hsiao, "Building an indoor air quality monitoring system based on the architecture of the Internet of Things", EURASIP Journal on Wireless Communications and Networking, Vol. 2021, pp.1-41, 2021.

[12] W. L. Cheng,Y. S. Chen, J. Zhang, T. J. Lyons, J. L. Pai and S. H. Chang, "Comparison of the revised air quality

index with the PSI and AQI indices”, Science of the Total Environment, Vol. 382, no. 2-3, pp.191-198, 2007.
[13] https://en.wikipedia.org/wiki/Dhaka#:~:text=Dhaka%20is%20a%20megacity%2C%20and,urban%20area%20in%20the%20world.
[14] https://www.macrotrends.net/cities/20119/dhaka/populat