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Air Quality Monitoring using IoT

Ms. Pooja Vajpayee [1], Jitendra Yadav[2], Asheesh Kumar[3], Ankur Gupta[4]

[1]Department of CSE, Raj Kumar Goel Institute of Technology, Ghaziabad poojafcs@rkgit.edu.in
[2]Department of CSE, Raj Kumar Goel Institute of Technology, Ghaziabad jitendrakumaryadav35570@gmail.com
[3]Department of CSE, Raj Kumar Goel Institute of Technology, Ghaziabad ashishkumar75497@gmail.com
[4]Department of CSE, Raj Kumar Goel Institute of Technology, Ghaziabad ankurg7275@gmail.com

ABSTRACT—

Air pollution is a growing concern in many urban areas, leading to adverse health effects and environmental damage. In response, air quality monitoring systems have been developed to measure the levels of pollutants in the air. With the emergence of the Internet of Things (IoT), these systems have become more accessible and scalable. This paper presents a study on the development and implementation of an IoT-based air quality monitoring system. The system is composed of low-cost sensors for measuring pollutants such as carbon monoxide, nitrogen dioxide, and particulate matter, and a central server for collecting and analyzing data. The system is designed to be scalable, allowing for the addition of more sensors as needed. The results of the study show that the system is capable of providing accurate and real-time air quality data. This data can be used to inform policy decisions and to provide citizens with information on air quality in their area. The study also identifies some challenges and limitations of the system, such as sensor calibration and data interpretation.

***Keywords*—IoT sensors, pollutants, Arduino, Central server, Data analysis, Real time, Scalable, low-cost, Accurate, Accessible, Data interpretation, Policy decisions, Public health, Environmental sustainability.**

I. Introduction

Air pollution has become a major global concern due to its adverse impacts human health and the environment in current situation. According to the World Health Organization (WHO), air pollution causes millions of premature deaths each year, mostly in low- and middle-income countries. In response, governments and organizations have implemented air quality monitoring systems to measure pollutant levels and inform policy decisions. With the emergence of the Internet of Things (IoT), these monitoring systems have become more accessible and scalable, enabling more widespread monitoring and real-time data analysis.

[1] In this paper, we present a study on the development and implementation of an IoT-based air quality monitoring system. The system is designed to be low-cost, scalable, and capable of measuring various pollutants, including carbon monoxide, nitrogen dioxide, and particulate matter. The system consists of a network of sensors connected to a central server, which collects and analyses data in real-time. The system is also designed to be easily customizable, allowing for the addition or removal of sensors as needed.

[2] The main objective of this study is to demonstrate the effectiveness and feasibility of an IoT-based air quality monitoring system in providing accurate and real-time air quality data. The paper will describe the hardware and software components of the system, as well as the calibration and data processing methods. We will also discuss the results of the study and the potential applications of the system for informing policy decisions and improving public health. Finally, we will identify some of the limitations and challenges of the system and suggest future directions for research in this field.

Among the most common sensors are the MQ135 and MQ-8, which can detect pollutants such as carbon dioxide, carbon monoxide, and various gases. These sensors can be integrated with a Node MCU or Arduino board, which can collect the data and transmit it to the cloud using a Wi-Fi module such as the ESP8266. The DHT11 sensor can also be used to measure temperature and humidity levels, which can provide additional context for the air quality data. With these sensors and devices, air quality can be monitored in real-time, allowing for early detection of air pollution and better management of environmental health risks. The server can be configured to receive and process the incoming data, which can be stored in a database and used to generate real-time visualizations or reports. These reports can be accessed by authorized users through a web-based dashboard, which can be accessed through a web browser.

Overall, the introduction for this research paper on an IoT-based air quality monitoring system establishes the importance of air quality monitoring due to its negative impact on human health and the environment. The rise of the Internet of Things (IoT) is also noteworthy, as it holds promising prospects for the future to provide more accessible and scalable air quality monitoring systems.

II. LITERATURE SURVEY

Air pollution is a global problem that threatens human health and the environment. Many studies have shown that long-term exposure to air pollution increases the risk of many health problems, including respiratory disease, heart disease and cancer. (Dockery et al., 1993; Pope et al., 2002). To address this issue, air quality monitoring systems have been developed to measure pollutant levels in the atmosphere. These systems are typically composed of expensive and bulky equipment, which limits their scalability and accessibility.

The difficulty with traditional monitoring devices is that they are large, heavy, and expensive. These lead to bad redirects. The locations of the monitoring station must be carefully placed to be effective because air pollution in urban areas is related to human activities (such as construction) and related areas of the monitoring site (such as construction).

Design and build an air monitoring system for combined monitoring of major pollutants and use wireless models for monitoring. The system uses semiconductor sensors to measure the concentration of gases such as CO, NO2 and SO2. The hardware combines a chip microcomputer, air pollution sensor array, GSM Module and GPS Module. The central server is a high-end PC application server with an internet connection. The hardware collects various pollutants and packs pollutants into a single frame with GPS physical location with time and date .The frame is finally assigned to the GSM-Modem and sent to the wireless network central server. The surrounding atmosphere has a significant impact on the composition of the atmosphere, leading to effects such as global warming and acid rain. Weather forecasting is important to avoid difficult situations. Air quality monitoring controlled by pollution authorities are expensive. Wireless sensor networks are a new and challenging area of research in the automation of embedded system design because designs must be strictly limited in terms of power and cost.

1. **Air Pollution Monitoring Using Node MCU:**

Arduino Poonam Pal1, Ritik Gupta2, Sanjana Tiwari3, Ashutosh Sharma.

Due to many factors that directly affect human health, such as population growth, increased traffic, industrialization, and urbanization, air pollution increases over time, people are exposed to the air pollution and therefore affect human health. Here, we will monitor the weather conditions based on IoT using sensors, monitor the air quality index in PPM(Parts Per Millions) from the web server using the internet, and give an alarm when the air quality drops below a certain level, that is, when there is a problem. Gases such as Carbon-Dixoide, smoke, alcohol, benzene and NH3 are present in sufficient quantities. It will show the air quality in PPM on the LCD and on the web page so we can monitor it very easily. In this project, you can monitor the pollution of any place using a web browser or mobile phone or tablet.

2. **IOT Based Air Pollution Monitoring System**:

Harsh N. Shah 1 , Zishan Khan 2 , Abbas Ali Merchant 3 , Moin Moghal 4 , Aamir Shaikh 5 , Priti Rane 6, Student, Diploma in Computer Engineering, BGIT, Mumbai Central, India 6 Assistant Professor, BGIT, Mumbai Central, India. Air pollution is the biggest problem facing any developing or developed country. Health problems are growing faster, especially in urban areas of the developing world, where industrialization and growth of traffic have led to the release of many pollutants. The dangers of air pollution range from minor allergies such as throat, eye and nose irritation to some serious problems.

3. **Air quality using ZigBee:**

This article discusses monitoring that provides information about the state of the environment and briefly describes developments in environmental monitoring that bring new perspectives to monitoring problems.

4. **Air Quality Monitoring Using Raspberry Pi:**

A draft environmental pollution monitoring system has been developed to monitor the concentration of pollutants. This system uses a low voltage power supply with a Wi-Fi which is connect in node MCU. The system uses semiconductor sensors to measure the concentration of gases such as Carbon-MonoOxide, Dioxides, Sulphur-dioxide and Nitrogen-dioxide. Create a MEAN group to view data on the web.

5. **Based Weather Monitoring System Using Arduino :**

Karthik Krishna murthi, Suraj Thapa, Lokesh Kothari, Arun Prakash Department of Computer Science, Christ University, Bangalore, India.

In this paper measure environmental factors such as temperature, humidity, dew point and temperature. The sensor reading is processed by the Arduino microcontroller and stored in a text file that can be processed for analysis. Readings are also displayed on the built-in LCD for quick viewing. All these readings can be analyzed to obtain weather characteristics of a particular area and record the weather. This information is important and varies from region to region.

III. Proposed system

An IoT-based weather monitoring system using MQ135 fuel sensors associated with the MCU node is proposed; The connected system wants to talk to the cloud via the the ESP8266 Wi-Fi module analyses the sensor data.

We use HTML,CSS creatin own website that connect to Wi-Fi with the help of IoT platform, we have a well defined derivative about the right PPM(parts Per Million) on the screen, and we have the right calibration. We achieve this at a lower cost, for example when we export data to the cloud, without having to look at the output of the LCD, which increases the cost of the project [1]. When we think of IoT as a platform, our goal should be to use a platform like Thinger to show this idea on the internet. bbeautifully designed io or ThingSpeak or Cayenne sites for outputting and even downloading files. While air quality monitoring is done, there is no need to use Liquid Petroleum Gas or methane or harmful gasses detection sensor as it is a safe home/office. Instead of using GSM or GPRS modules [2], we use Wi-Fi to send data to the any cloud platforms. The main problem in another document mentioned in [3] is it doesn't calibrate the sensor or even change the sensor output value to PPM. According to United Nations guidelines, 0-50 PPM is a safe value and 51-100 is an average value. Delhi is the world's most polluted city on record at 250PPM. It takes more energy (P = V * I) as we are using three sensors, these all three sensors with internal thermal elements, so even if all sensors are enabled, the output voltage will change because the driver is underpowered and unreliable. . That's why we use a 9V battery or connected to adapter power supply and a 7805 series LM7805 voltage regulator for the CO sensor MQ138..

We are using the Arduino Uno development kit (IDE) that comes with the ATMega328P microcontroller. To provide Wi-Fi support, we use the affordable ESP-2866 Wi-Fi module, which helps us connect to the central server IoT platform. The connection between them is indicated in the attached diagram.

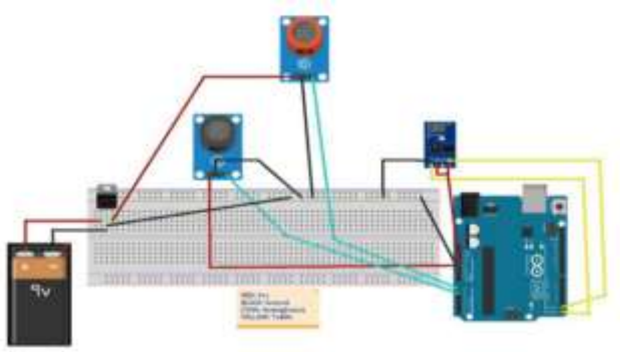

FIG. 3.1 Connection Diagram

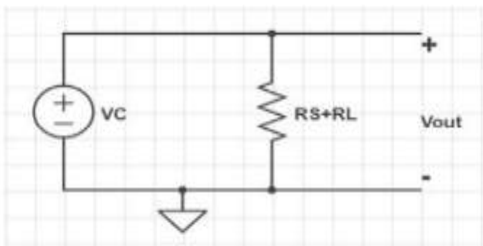

Fig. 3.2. Internally circuit diagram of MQ-135

A. An air quality monitoring using IoT involves the integration of the Internet of Things (IoT) technology with air quality monitoring module. This integration allows for the collection and analysis of air quality data in real-time using low-cost and scalable sensors. To refer to such a system, several abbreviations and acronyms can be used, such as IoT-AQMS, IoT-AQS, and IAQMS-IoT.

Air quality can be measured using several units depending on the specific pollutants being monitored. Here are some common units used to measurement air quality index:

Particulate matter (PM): measured in micrograms per cubic meter ($\mu g/m^3$)Ozone

(O_3): measured in parts per billion (ppb)

Sulfur dioxide (SO_2): measure parts per billion (ppb)

Nitrogen dioxide (NO_2): measured in parts per billion (ppb) or micrograms per cubic meter ($\mu g/m^3$)

Volatile organic compounds (VOCs): measured in parts per billion (ppb) or parts per million (ppm)

The most important step ne necessary step is to adjust the sensor in a setting with clean air to establish a baseline measurement, then draw an equation that converts the sensor output voltage value into three simple PPM units. Here is code in [1].

According to the Ohm's Law, if the temperature is constant, we can say I as follow:

$$I = V/ R \qquad (1)$$

From fig ,the equation 1 is equivalent to the

$$I = Vc/Rs + R_1 \quad (2)$$

From , we can obtain the output voltage at the load resistor using the value obtained for I and Ohm's Law at constant temperature. V = I*R

$$VR_1 = [\ Vc/\ Rs + R_1] * RL \quad (3)$$

Modify above equation (3), then we get

$$VR_1 = [\ Vc * R_1[Rs + R_1] \quad (4)$$

$$(VR_1 * Rs) + (VR_1 * R_1) = Vc * RL \quad (5)$$

$$VR_1 * Rs = (Vc * R_1) - (VR_1 * R_1) \quad (6)$$

$$Rs = (Vc * R_1) - (VR_1 * R_1)\ VR_1 \quad (7)$$

$$Rs = (Vc * R_1)\ VR_1 - R_1 \quad (8)$$

Obtained eequation 9 helping out find the internal sensor resistance for fresh air

$$Rs = (Vc * R_1) / VR_1 - R_1 \quad (9)$$

To calculate R_0 just we need to find the value of Rs in clear air. This can be done by taken an analog average reading from the sensors and convert all values it to voltage. We will see R_0 using the Rs model. First, we will consider the line as linear. This allows us to use the formula that relates ratio linearly to concentration. By doing this, we can find more oil for each price index, even outside the borders. Obtained formula we will use is the equation of a straight line, but on a log-log scale. The formula for the straight line is [9]:

From Figure 3 above, we try to calculate the following.

$$y = m*x + b \quad (10)$$

For a log-log scale, the formula looks like this:

$$\log10y = m * \log10x + b$$

Now that we have m, we can calculate the y intercept. To do so, we need to choose one point from the graph (once again from the CO2 line). In our case, we chose (5000,0.9)

$$\log(y) = m * \log(x) + b \quad (17)$$

$$b = \log(0.9) - (-0.318) * \log(5000)\ (18)\ b = 1.13 \quad (19)$$

Now that we have m and b, we can find the gas concentration for any ratio with the following formula:

$$\log(x) = \log(y) - bm \quad (20)$$

However, in order to get the real value of the gas concentration according to the log- log plot we need to find the inverse log of x: x = 10 / m

Using equations 9 and 21, we will be able to convert the sensor output values into PPM (Parts per Million). Now we developed the Code and flashed into the Arduino Uno giving proper connections as mentioned.

IV. System Design

We use LCD, Power, Jumper, MQ135 Air Quality Sensor and Node MCU to detect CO2, CO, Ammonia and Smoke as hardware. After is also called ESP8266 wifi chip to Node MCU, why do we use, that means we need to transfer data to cloud, because Arduino has no wifi, so we use chip and make this wifi hotspot 5V for our phone We connect it to the power supply It is currently one of the most used power supplies for the.The H44780 Character LCD is an industry standard LCD display device designed to interface with embedded systems. Here in this project we are using 16X2 Configuration 4-bit write mode. We use the generator at Buzzer. For software we use a platform called Things to Say.

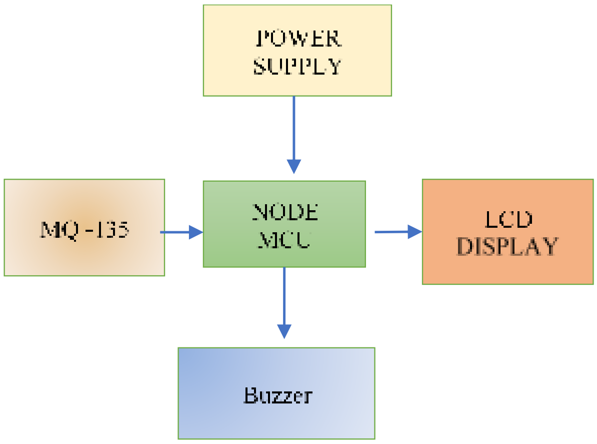

Figure 4.1: Block Diagram Air Quality Monitoring System

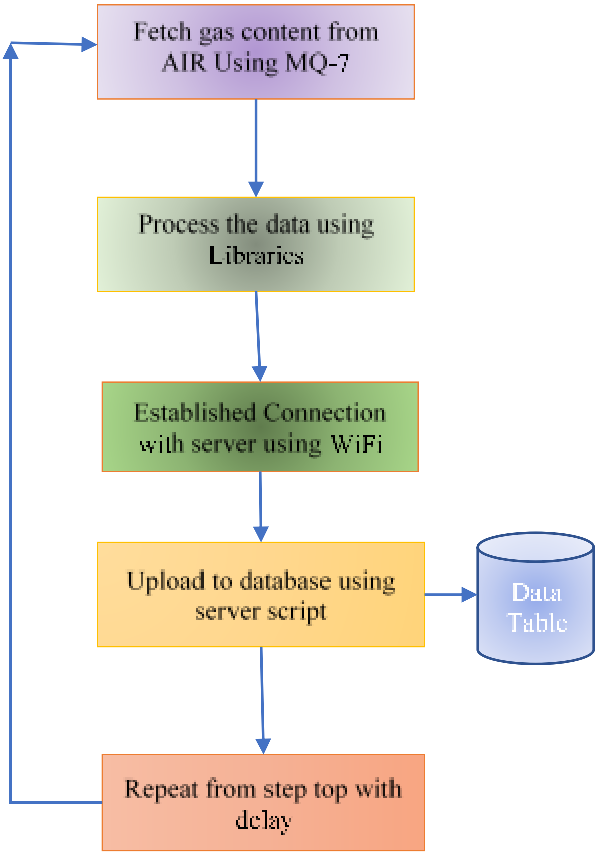

Figure 4.2: Flow Chart of Air Quality Monitoring System

V. Result and Discussion

The ESP8266 Wi-Fi module allows the program to access Wi-Fi or the Internet. This is a very affordable tool that makes your plans so powerful. It can communicate with any microcontroller and is the most advanced device in the IoT platform. Find out more here. Then we interface the MQ135 sensor with Arduino.Connect the VCC and ground pin of the sensor to the 5V and ground of the Arduino and the analog pin of the sensor to the A0 of the Arduino. Connect the buzzer to the 8th pin of the Arduino, the buzzer will start beeping when the event is over. MQ135 sensor can detect NH_3, NO_x, alcohol, benzene, smoke, CO_2 and other gases, it is the best gas sensor for our air quality monitoring.

Figure 5.1: Data show on web browser

After the wifi connection with the ESP-01 is completed, it will connect to the ThingSpeak account with the help of the API key we have provided. ThingSpeak requires a 15 second delay to transmit data. Figure 7 shows a graph of MQ135 and MQ7 sensor values converted to PPM [7] [8]. Figure 8 shows the statistical analysis of the results against time on the X-axis and against air PPM on the Y-axis..

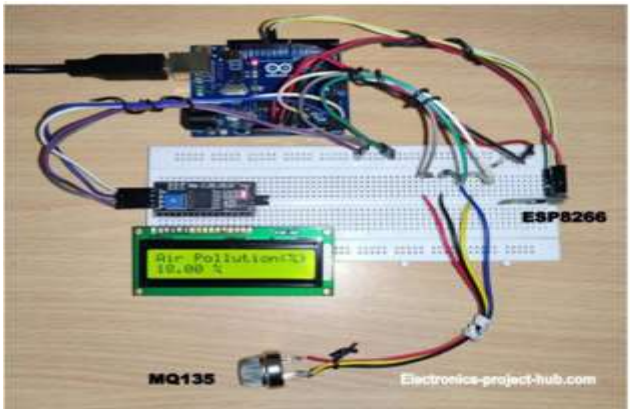

Figure 5.2: Display on LCD

In manufacturing and quality control, PPM is used to measure the defect rate in a production process. For example, if a manufacturing process produces one defective unit for every million units produced, the defect rate can be expressed as one PPM. PPM is used to express the concentration of a particular substance or element within a larger sample.

In environmental monitoring, PPM is used to measure the concentration of pollutants or other substances in the air, water, or soil. For example, the concentration of a particular gas in the atmosphere can be expressed as a certain number of PPM.

VI. Conclusion

Air quality monitoring using IoT (Internet of Things) devices has become an increasingly popular approach to track and manage air pollution levels in a given environment. Here are some key conclusions that can be drawn from air quality monitoring using IoT:

- IoT-based air quality monitoring systems provide real-time data on air pollution levels, allowing for better-informed decision-making regarding public health and environmental policy.
- The use of IoT devices for air quality monitoring can help identify the sources of air pollution, enabling policymakers to design more targeted interventions aimed at reducing pollution levels.
- IoT-based air quality monitoring systems can be used to alert the public and relevant authorities of potentially hazardous air quality levels, allowing for timely action to protect public health.
- IoT devices for air quality monitoring are often portable and easy to use, enabling more widespread adoption and empowering individuals and communities to monitor air quality levels in their own environment.
- The use of IoT technology in air quality monitoring can lead to more cost-effective and efficient monitoring, as data can be collected and analyzed.

- The proliferation of IoT-based air quality monitoring systems can help raise public awareness of air pollution levels and encourage individuals to take steps to reduce their own contributions to air pollution.
- The continued development of IoT technology is likely to lead to more advanced and sophisticated air quality monitoring systems, enabling more precise measurement of air pollution.

In conclusion, the use of IoT technology for air quality monitoring offers many benefits, including real-time monitoring, better-informed decision-making, and more targeted interventions aimed at reducing air pollution levels. The technology also has the potential to raise public awareness and empower individuals to take action to reduce their own contributions to air pollution.

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