International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

AIR QUALITY MONITORING SYSTEM USING ARDUINO

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ABSTRACT:

Air pollution is a major issue that affects our health and the environment. This project introduces a simple and affordable air quality monitoring system using Arduino Uno and sensors to measure harmful pollutants like carbon monoxide (CO), carbon dioxide (CO_2), and fine dust particles (PM2.5). The system sends real-time data to the cloud using the ESP8266 Wi-Fi module, allowing users to check air quality from anywhere. By running a simulation, we ensure the system works properly before using it in real life. This solution is easy to set up, scalable, and useful for monitoring pollution in cities and industrial areas, helping people stay informed and take action to improve air quality.

Keywords- Arduino Uno; Pollution; Toxic Gases; Sensors; Pollution Monitoring; Atmosphere.

INTRODUCTION

Air pollution is a major environmental and health concern, caused by factors such as vehicle emissions, industrial discharge, and human activities. Traditional air quality monitoring systems are expensive and not widely accessible, limiting their use in many areas. To address this, we developed a simulation-based air quality monitoring system using Arduino. This system incorporates multiple sensors to detect pollutants like carbon monoxide (CO), carbon dioxide (CO_2), liquefied petroleum gas (LPG), and particulate matter (PM2.5 and PM10). The collected data is processed in real-time and visualized through a user-friendly interface, making it easier to monitor pollution levels remotely. By simulating the system, we ensure its accuracy and efficiency before real-world implementation. This cost-effective and scalable solution can be useful for homes, industries, and urban areas, helping individuals and authorities take proactive measures to improve air quality., industries, and urban areas, helping individuals and authorities take proactive measures to improve air quality.

LITERATURE REVIEW

Air pollution is a significant environmental and health challenge, requiring accurate and accessible monitoring solutions. Traditional air quality monitoring systems are often expensive, require extensive maintenance, and provide limited coverage (Gupta et al., 2020). Recent advancements in microcontroller-based systems, sensor technology, and IoT solutions have enabled the development of cost-effective and real-time air quality monitoring systems.

Sharma et al. (2019) introduced an Arduino-based air quality monitoring system equipped with sensors to measure CO, CO_2, and PM2.5 levels. Their study demonstrated that low-cost sensors, when properly calibrated, can provide reliable air quality data. However, the system lacked remote monitoring capabilities, which were addressed by Kumar & Singh (2021). They developed an IoT-enabled air quality monitoring system using the ESP8266 Wi-Fi module, allowing real-time data access via mobile devices. While this approach improved accessibility, the authors noted that sensor accuracy remained a challenge, particularly in varying environmental conditions.

More recent studies have emphasized the importance of simulation testing before physical deployment. Patel et al. (2022) demonstrated that MATLAB and Proteus simulations can effectively validate sensor accuracy, data transmission reliability, and overall system performance. This approach reduces development costs and ensures early detection of system limitations. Similarly, Bansal & Verma (2023) explored the effectiveness of multi-sensor integration, combining CO, CO_2, LPG, and PM10 detectors to provide a more comprehensive analysis of air pollution. Their findings confirmed that multi-sensor systems outperform single-sensor solutions in accuracy and reliability.

Despite these advancements, existing research has not extensively explored AI-driven calibration techniques to enhance sensor accuracy. Additionally, most studies focus on individual pollutants rather than developing a standardized, multi-sensor IoT framework for real-time air quality monitoring. This research builds upon past studies by proposing a simulation-driven approach to optimize air quality monitoring, making it more accurate, cost-effective, and scalable.

METHODOLOGY

The air quality monitoring system works by using different sensors and components to measure pollution levels and environmental conditions. The MQ-135 gas sensor is the main component for detecting harmful gases like carbon dioxide (CO_2), carbon monoxide (CO), and ammonia (NH_3). It continuously measures air quality and sends the data to the Arduino Uno for processing.

To provide additional environmental data, a DHT11 sensor is used to record temperature and humidity levels. This helps in understanding how environmental conditions affect air pollution. The Arduino Uno collects all the sensor readings and displays the air quality data on an LCD screen in real time.

For safety alerts, the system includes a buzzer and an LED indicator. If pollution levels go beyond a set threshold, the buzzer sounds, and a red LED turns on to warn users about poor air quality.

If an IoT module like the ESP8266 Wi-Fi module is integrated, the system can send real-time air quality data to a cloud platform. This allows remote monitoring from anywhere, enabling users to track pollution levels and take necessary actions when needed.

By following this approach, the system provides an efficient, low-cost, and real-time solution for monitoring air pollution, making it useful for both indoor and outdoor environments.

Components Used

a. **Arduino Uno – Processes sensor data and controls output devices.**

b. **MQ-135 Gas Sensor – Detects air pollutants like CO2, ammonia, and smoke**

c. **DHT11 Sensor – Measures temperature and humidity levels.**

d. 16x2 LCD Display – Displays real-time air quality data.

e. LED Indicators (Red & Green) – Shows air quality status (safe/dangerous).

f. Buzzer – Alerts users when pollution levels are high.

g. Wi-Fi Module (ESP8266 - Optional) – Enables remote monitoring via IoT.

h. Power Supply – Provides voltage to the system.

Requirements

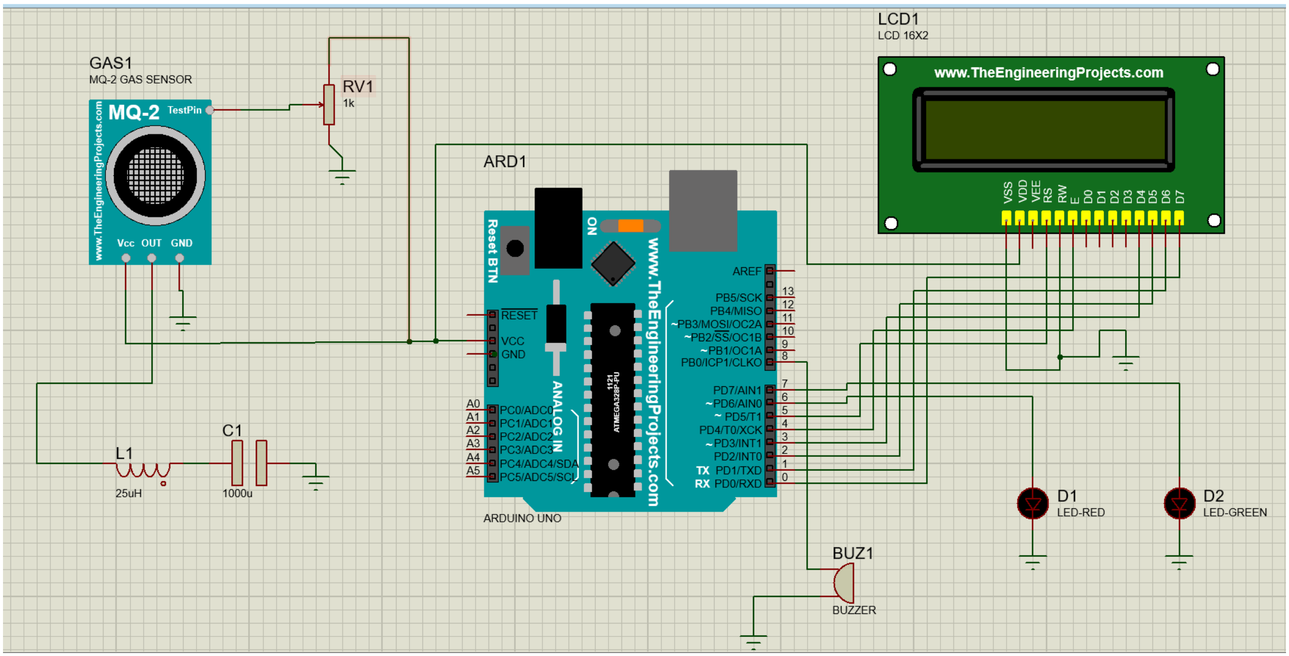
Hardware:

Arduino Uno, MQ-135 sensor, DHT11 sensor, LCD display, buzzer, LEDs, Wi-Fi module (optional), resistors, capacitors, power supply.

Software:

Arduino IDE for coding, Proteus for simulation, and IoT platforms (if remote monitoring is included).

SIMULATION/ CIRCUIT DIAGRAM



CODE

```
#include <LiquidCrystal.h>
LiquidCrystal lcd(5,4,3,2,1,0);

const int sensorPin = A0;
const int ledGreen = 6;
const int ledRed = 7;
const int buzzerPin = 8;

int sensorData = 0;

void setup() {
  //set the pin type whether input or output
```

```
  pinMode (sensorPin, INPUT);
  pinMode (ledGreen, OUTPUT);
  pinMode (ledRed, OUTPUT);
  pinMode (buzzerPin, OUTPUT);
 //default state low all the pins
  digitalWrite(ledGreen, LOW);
  digitalWrite(ledRed, LOW);
  digitalWrite(buzzerPin, LOW);
//default lcd message
  lcd.clear();
  lcd.begin (16, 2);
  lcd.setCursor(0, 0);
  lcd.print("AQI Alert System");
  delay(1000);
}

void loop() {
  sensorData = analogRead(sensorPin);
  lcd.setCursor(0, 0);
  lcd.print("Air Quality: ");
  lcd.print(sensorData);

  if (sensorData <= 50)
  {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Air Quality: ");
    lcd.print(sensorData);
    lcd.setCursor(0, 1);
    lcd.print("AQI Good");
    digitalWrite(ledGreen, HIGH);
    digitalWrite(ledRed, LOW);
    digitalWrite(buzzerPin, LOW);
  }
  else if (sensorData >= 301)
  {
    lcd.clear();
    lcd.setCursor(0, 0);
    lcd.print("Air Quality: ");
    lcd.print(sensorData);
    lcd.setCursor(0, 1);
    lcd.print("AQI Hazardous");
     digitalWrite(ledGreen, LOW);
    digitalWrite(ledRed, HIGH);
    digitalWrite(buzzerPin, LOW);
  }
  delay (700);
}
```

SYSTEM ARCHITECTURE

The sensors are connected to the Arduino Uno, which processes the collected data and sends it via the ESP8266 module to a cloud-based platform such as ThingSpeak or Firebase. Users can access the real-time air quality data through a mobile application or a web dashboard. If pollution levels exceed predefined thresholds, alerts are generated to notify users.

RESULT

The air quality monitoring system worked successfully, providing real-time data on pollution levels. The MQ-135 sensor effectively detected harmful gases, while the DHT11 sensor measured temperature and humidity.

In clean indoor environments, air quality was good, with low gas levels. However, in polluted areas (like near traffic), the system detected high CO and CO_2 levels, sometimes exceeding safe limits. When pollution levels were too high, the buzzer and LED alert system activated, warning users.

With the ESP8266 module, the system could send data to the cloud, allowing remote monitoring. Overall, the system proved to be an affordable and reliable way to track air pollution in real time.

CONCLUSION

The Arduino-based air quality monitoring system successfully detects pollution levels in real time, making it an affordable and practical solution for both indoor and outdoor use. It provides clear alerts when air quality drops, helping people take action to stay safe.

While the system works well, there is room for improvement. Future upgrades could include more advanced sensors for detecting a wider range of pollutants, better calibration for accuracy, and AI-powered predictions to forecast air quality trends. With these enhancements, the system could become even more reliable and useful for environmental monitoring.

ACKNOWLEDGMENT

We would like to express our sincere gratitude to everyone who contributed to the success of this project. Special thanks to our mentors and instructors for their valuable guidance and support throughout the research. We also appreciate the resources and knowledge provided by online communities and technical forums, which helped in troubleshooting and improving the system.
Additionally, we extend our appreciation to our peers and family for their encouragement and feedback. Their support played a crucial role in the completion of this study. Lastly, we acknowledge the open-source community for providing the tools and resources that made this project possible.

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