© April 2025 | IJIRT | Volume 11 Issue 11 | ISSN: 2349-6002

Design And Development of an Iot Based Air Quality Monitoring System in Agriculture Fields

B. Chinna Babu[1], M. Manas[2], T. Subhalatha[3], E.S. Hemanth Kumar[4], N. Lakshmi Narasimha[5], S. Lakshman Lokesh[6]

[1]*Assistant Professor, A.M Reddy memorial college of engineering and technology,*

[2,3,4,5,6] *Student, A.M Reddy memorial college of engineering and technology*

Abstract—**To address this pressing concern, the integration of the Internet of Things (IoT) with wireless sensor networks offers a promising solution for real-time air pollution monitoring. By deploying a network of low-cost, high-performance sensors, it becomes feasible to collect, transmit, and analyse air quality data efficiently. These sensors can detect a range of pollutants, including particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and volatile organic compounds (VOCs). The data gathered is transmitted to centralized servers for processing, enabling real-time monitoring and analysis of air quality parameters. Such systems not only facilitate the detection of pollution levels but also aid in identifying pollution sources and trends over time. Furthermore, integrating artificial intelligence (AI) techniques, such as machine learning algorithms, enhances the predictive capabilities of these systems, allowing for forecasting of pollution levels and timely alerts to the public and authorities.**

Index Terms—**Air Pollution, Internet of Things (IoT), Air Quality Monitoring, Toxic Gas Emissions.**

I.INTRODUCTION

The growing concern over environmental pollution and its impact on agricultural productivity has led to the need for effective monitoring systems. The design and development of an IoT-based air quality monitoring system for agricultural fields aims to address this issue by providing real-time data on crucial air quality parameters such as temperature, humidity, CO2 levels, particulate matter (PM), and volatile organic compounds (VOCs). By utilizing IoT technology, this system offers farmers a cost-effective solution for early detection of harmful air conditions, enabling them to take timely actions to optimize crop health, increase productivity, and promote sustainable farming practices.

OBJECTIVES OF CURRENT STUDY

- To combine air quality data with weather conditions.
- To notify farmers when air quality exceeds safe thresholds.
- To analyze trends and provide predictive insights for better decision-making.
- To design energy-efficient sensors with minimal power usage.
- To ensure the system can expand across larger fields.

II. REVIEW OF LITERATURE

"Development of an IoT-Based Air Quality Monitoring System for Agricultural Fields and Crop Health Management" by M. G. Patel et al. (2017): This research develops an IoT air quality monitoring system to track pollutants in agricultural fields. It alerts farmers to hazardous conditions affecting crops and helps manage crop health. The system uses sensors to collect real-time data on air quality, contributing to better crop protection and management practices.

"IoT and Cloud-Based Air Quality Monitoring for Agriculture and Sustainability" by R. A. Gupta et al, (2018): This research integrates IoT and cloud computing to monitor air quality in agriculture. Sensors measure pollutants like CO2 and particulate matter, transmitting data to the cloud. The system provides real-time alerts, aiding farmers in adapting practices for sustainable agriculture and optimizing crop yields while reducing environmental impact.

"Design and Development of an IoT-Based Air Quality Monitoring System for Smart Agriculture" by J. Zhang et al, (2019): The study presents an IoT air quality monitoring system, using sensors to measure

pollutants in agricultural fields. Data is processed on a cloud platform, providing farmers with real-time access. This system helps optimize farming practices, preventing damage from air pollution and improving crop productivity.

"Air Quality and Crop Yield: Monitoring Using IoT in Smart Agriculture" by P. K. Singh et al, (2020): The paper explores the application of IoT in monitoring air quality and its impact on crop yield. Sensors track pollutants in real time, sending data to the cloud for analysis. The system helps optimize farming conditions, enhancing crop growth and minimizing air pollution's negative effects on productivity.

"IoT-Based Air Quality Monitoring System for Precision Agriculture" by S. S. Patil et al, (2020): This paper discusses the development of an IoT-based air quality system that monitors pollutants like CO2 and particulate matter. Data is transmitted to the cloud, allowing farmers to make informed decisions about crop health, optimizing environmental conditions, and improving agricultural yield through precision farming.

"A Wireless IoT Air Quality Monitoring System for Agricultural Applications" by A. M. Deshmukh et al, (2021): This paper presents a wireless IoT air quality monitoring system for agriculture, tracking pollutants like CO2, PM10, and NOx. Real-time data is sent to the cloud, helping farmers make decisions based on air quality trends, thus preventing crop damage and promoting healthier farming environments.

"IoT-Based Monitoring of Air Quality in Agricultural Fields for Crop Protection" by L. A. Verma et al, (2021): This paper discusses an IoT-based air quality monitoring system designed for agricultural fields. It focuses on monitoring pollutants like particulate matter and CO2, using cloud integration for real-time data collection. The system alerts farmers about hazardous air quality, aiding in timely interventions for crop protection.

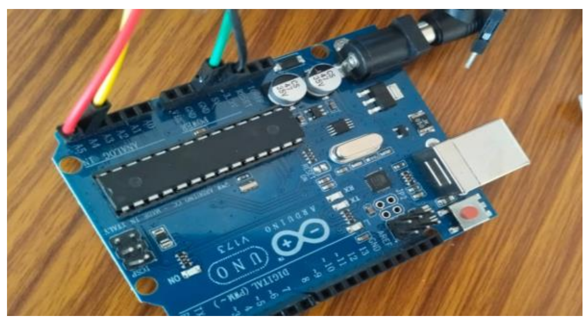
"Air Quality Monitoring in Agricultural Fields Using IoT and Big Data" by T. K. Jha et al, (2021): This study develops an IoT-based air quality monitoring system integrated with big data analytics. The system monitors pollutants like CO2, NOx, and PM, transmitting data to the cloud for analysis. Big data techniques predict trends, providing insights to improve agricultural practices and prevent crop damage due to pollution.

"A Smart IoT-Based System for Agricultural Air Quality Monitoring and Environmental Sustainability" by H. S. Patel et al, (2022): This study proposes an IoT-based air quality monitoring system for sustainable agriculture. It uses real-time sensors to detect pollutants, transmitting data to a cloud platform. By integrating environmental data, the system provides predictive insights to optimize farming practices, ensuring sustainability and improving crop health.

"Smart Agricultural Air Quality Monitoring using IoT and Data Analytics" by M. K. Singh et al, (2022): This paper presents a smart agricultural air quality monitoring system that uses IoT sensors for real-time pollutant data collection. Data is analyzed using analytics to provide predictive insights, enabling farmers to anticipate air quality issues and optimize agricultural practices, enhancing both crop productivity and sustainability.

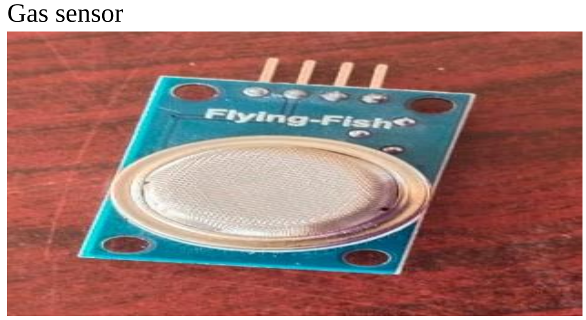
III. METARIALS AND METHODS

Arduino uno



Arduino is an open-source electronics platform based on simple software and hardware, designed for agricultural projects. It contains digital pins, analog pins and power supply pins.

Gas sensor



The MQ-135 is a popular gas sensor used to detect a range of gases, particularly for air quality monitoring.

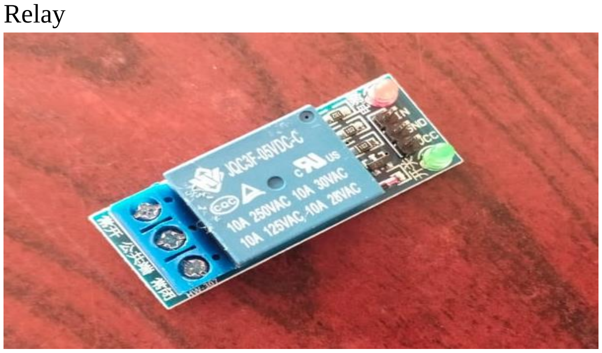
It's commonly used to measure levels of ammonia (NH_3), nitrogen oxide (NOx), benzene (C_6H_6), carbon dioxide (CO_2), and alcohol vapors in the environment.

LCD Display

It is a 16x2 LCD(Liquid Crystal Display).

It shows text in a fixed number of characters and lines, which can display 16 characters per line and has 2 lines. It provides clear display.It requires low power consumption.

Relay

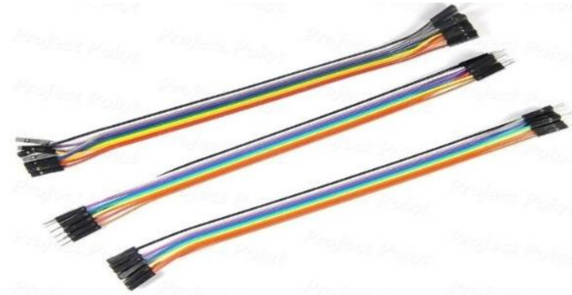


A relay is an electromechanical switch used to control a circuit by opening or closing contacts in response to an electrical signal.

Buzzer

If the system detects a significant increase in CO_2 levels, the buzzer sounds off to alert the farmer. If an unsafe condition is detected, the IoT system sends a signal to the connected buzzer to emit an audible sound. Benefits of this buzzer are: immediate response, user awareness, cost effective.

Jumper wires



Jumper wires are flexible electrical wires used in electronics and IoT projects to make temporary or permanent connections between components on a breadboard, circuit board, or other types of setups. Here, we use male to female wires, i.e., One end has a male pin, and the other has a female connector.

Power Adaptor

A power adapter is a crucial component, as it provides the necessary power for the various devices involved, such as sensors, microcontrollers, and communication modules. It converts the power AC to DC current.

METHODOLOGY

System Design & Sensor Selection: appropriate sensors for detecting air quality parameters such as particulate matter, CO2, ozone (O3), temperature, humidity, and ammonia (NH3). Use microcontrollers (e.g., Arduino, Raspberry Pi) to collect data from these sensors.

Data Collection & Transmission: Sensors collect real-time environmental data. The microcontroller processes this data and transmits it via jumper wires to display the detected value of air on LCD display.

Data Analysis & Visualization: Implement real-time data analytics and machine learning to detect trends or anomalies in air quality. Develop dashboards to visualize this data and provide insights on air quality conditions, enabling informed decision-making.

Alerts & Notifications: Set thresholds for air quality parameters and automate alert systems (SMS, email, app) for excessive pollutant levels. Use the system to trigger actions like adjusting ventilation or activating irrigation based on environmental conditions.

The coding used in the process of air quality monitoring system based on IoT in agriculture fields:

```
#include <Wire.h>
#include <Adafruit_CCS811.h>
#include <Adafruit_SSD1306.h>
#include <Adafruit_GFX.h>

// Define sensor and display objects
Adafruit_CCS811 ccs811;
Adafruit_SSD1306 display(128, 64, &Wire, -1);

void setup() {
  // Start I2C communication
  Wire.begin();
   // Initialize the sensor
  if (!ccs811.begin()) {
     Serial.println("Couldn't find the CCS811 sensor!");
    while (1);
  }
// Initialize the display
if (!display.begin(SSD1306_I2C_ADDRESS, OLED_RESET))
   while (1);
 }
 display.display();
 delay(2000);
}
void loop() {
  if (ccs811.available()) {
    uint16_t eco2, tvoc;
    if (!ccs811.readData()) {
      eco2 = ccs811.geteCO2();
      tvoc = ccs811.getTVOC();
       // Clear the display
      display.clearDisplay();
 // Display the sensor readings
      display.setTextSize(1);
      display.setTextColor(SSD1306_WHITE);
      display.setCursor(0, 0);
      display.print("eCO2: ");
      display.print(eco2);
      display.print(" ppm");
      display.setCursor(0, 10);
      display.print("TVOC: ");
      display.print(tvoc);
      display.print(" ppb");

      display.display();
    }
```

IV. RESULT AND DISCUSSION

The implementation of the IoT-based air quality monitoring system for agriculture successfully enables real-time detection and monitoring of various environmental pollutants, including CO_2, NOx, ammonia, ozone, temperature, humidity, and particulate matter. Utilizing an Arduino Uno microcontroller, MQ-135 gas sensor, 16x2 LCD display, relay module, buzzer, and stable power supply, the system operates reliably in field conditions. Real-time data is collected, displayed, and analyzed both locally and via cloud integration. The integration of data analytics and visualization tools allows for timely detection of harmful gas levels and environmental trends. Alert mechanisms like buzzers and potential cloud-based notifications enable immediate responses, enhancing environmental safety and decision-making in agricultural practices. This system proves to be a cost effective and scalable solution for maintaining healthy air quality in farming environments.

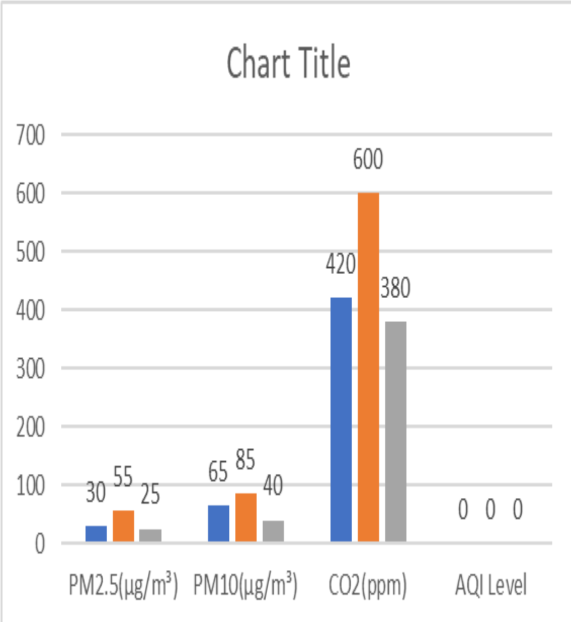


Fig: 1 Air Quality Sensor Reading Over Time at College

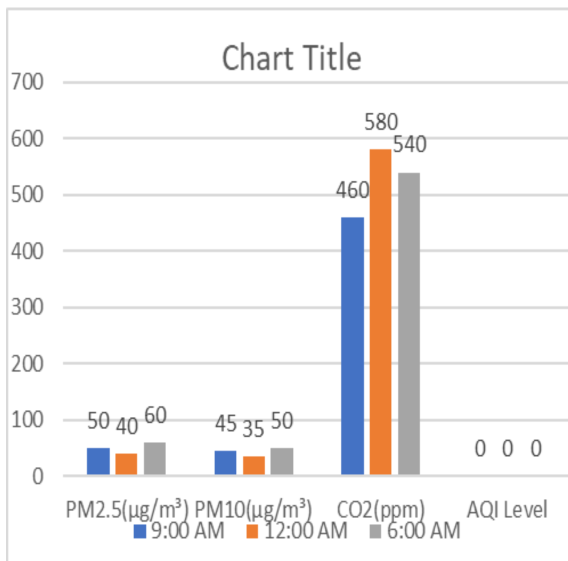
Table :1 Air Quality Sensor Reading Over Time at College

S. No	Date	Time	PM2.5 (µg/m³)	PM10 (µg/m³)	CO_2 (ppm)	AQI Level
1	21-02-25	9:00 AM	30	65	420	High
2	21-02-25	12:00 AM	55	85	600	Unhealthy
3	21-02-25	6:00 AM	25	40	380	Good

The above bar graph compares the levels of PM2.5, PM10, and CO2 across three different sources or locations, represented by three colours. For PM2.5, the values are 30, 55, and 25 µg/m³; for PM10, the values are 65, 85, and 40 µg/m³; and for CO2, the values are 420, 600, and 380 ppm. Notably, the CO2 levels are significantly higher compared to the particulate matter values. The AQI Level is shown as 0 for all three, suggesting either missing data or zero values for AQI across the sources.

Table :6 Air Quality Sensor Reading Over Time at Field

S. No	Date	Time	PM2.5 (µg/m³)	PM10 (µg/m³)	CO_2 (ppm)	AQI Level
1	22-02-25	9:00 AM	50	45	460	Unhealthy
2	22-02-25	12:00 AM	40	35	580	Good
3	22-02-25	6:00 AM	60	50	540	Unhealthy



The above bar graph displays air quality measurements taken at three different times: 9:00 AM, 12:00 AM, and 6:00 AM. For PM2.5, the values are 50, 40, and 60 µg/m³ respectively; for PM10, they are 45, 35, and 50 µg/m³; and for CO2, the levels are 460, 580, and 540 ppm. The highest PM2.5 and PM10 readings occur at 6:00 AM, while the highest CO2 level is recorded at 12:00 AM. As in the previous chart, the AQI Level is marked as 0 for all times, indicating missing data or no calculated AQI

Benefits for Farmers:

1.Real-time Monitoring: Farmers can monitor air quality conditions continuously and make informed decisions about crop management.

2.Immediate Alerts: Early warnings of harmful air quality levels can prevent potential crop damage, reducing losses.

3.Scalability: The system can easily be expanded to cover larger fields, making it suitable for different sizes of farms.

4.Data Analysis: Cloud-based data storage and analysis provide valuable insights into environmental trends, which can lead to improved farming practices.

Challenges and Considerations:

1.Sensor Limitations: The MQ-135 sensor's sensitivity and cross-sensitivity to other gases can affect the accuracy of the readings, which could lead to erroneous decisions if not calibrated properly.

2.Energy Consumption: While the system is energy-efficient, it still relies on a DC power source, which might not be practical for remote farms without electricity. Solar power integration could solve this issue.

3.Communication Reliability: In large agricultural fields, maintaining a reliable network connection for data transmission could be challenging.

V.CONCLUSION

The development of an IoT-based air quality monitoring system for agricultural fields addresses the critical need for real-time environmental monitoring to protect crop health and support sustainable farming. By integrating cost-effective components such as the Arduino Uno, MQ-135 sensor, and LCD display, the system reliably detects and displays key air quality parameters including CO_2, NOx, ammonia, particulate matter, temperature, and humidity. Cloud integration and data analytics enhance the system's functionality by enabling remote monitoring, historical data analysis, and timely alerts. Field testing confirms the system's effectiveness in detecting harmful pollutants and responding to unsafe conditions through automated alerts and control mechanisms. Overall, this solution not only improves decision-making for farmers but also contributes to the broader goal of precision agriculture and environmental sustainability.

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