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Air Quality Monitoring System

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Abstract: *The Air Quality Monitoring System (AQMS) is a technological solution designed to continuously measure and assess air quality in a given environment. It is a crucial aspect of ensuring the health and well-being of individuals within any environment, particularly in densely populated areas like colleges and universities. The air quality in educational institutions can be affected by various factors such as industrial emissions, vehicular pollution, and natural environmental conditions. Implementing an air quality monitoring system helps identify pollutants, track changes over time, and develop strategies to improve air quality, promoting a safer and healthier environment for students, staff, and visitors. The primary aim of the AQMS is to provide real-time, accurate data that can be used for environmental monitoring, regulatory compliance, and public health management.*

Keywords: Air Quality Monitoring, AQI (Air Quality Index), Environmental Monitoring, Real-Time Monitoring, Pollution Control

I. INTRODUCTION

Air is getting polluted because of release of toxic gases by industries, vehicle emissions and increased concentration of harmful gases and particulate matter in the atmosphere. The level of pollution is increasing rapidly due to factors like industries, urbanization, increasing in population, vehicle use which can affect human health. Particulate matter is one of the most important parameter having the significant contribution to the increase in air pollution. This creates a need for measurement and analysis of real-time air quality monitoring so that appropriate decisions can be taken in a timely period. This paper presents a real-time standalone air quality monitoring. Internet of Things is nowadays finding profound use in each and every sector, plays a key role in our air Quality monitoring system too. The setup will show the air quality in PPM in webpage so that we can monitor it very easily. In this IoT project, you can monitor the pollution level from anywhere using your computer or mobile.

II. PROBLEM STATEMENT

With increasing urbanization, industrial activities, and vehicle emissions, air quality is deteriorating rapidly in many regions worldwide. Existing air quality monitoring systems are often stationary, costly, and lack real-time reporting. This creates a significant challenge in assessing air pollution in real time and making timely decisions to protect human health. Therefore, the problem is to design and develop an affordable, real-time, and portable air quality monitoring system that can detect key air pollutants such as PM2.5, PM10, CO2, CO, NO2, and volatile organic compounds (VOCs) across different environments.

III. LITERATURE REVIEW

Air quality monitoring has become increasingly important due to rising urban pollution levels and their impact on human health. Traditional monitoring stations, while accurate, are often expensive and limited in coverage. Recent studies have explored Arduino Unobased systems as a low-cost, portable, and scalable alternative.

Low-Cost Sensor Integration : Sharma et al. (2019) demonstrated that Arduino Uno, when paired with sensors like MQ-135 (for CO_2, NH_3, and benzene) and PMS5003 (for PM2.5), can provide reliable air quality data after proper calibration. Their work highlighted the importance of sensor calibration to match reference-grade instruments

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Multi-ParameterMonitoring : Research by JETIR (2023) integrated MQ-7 (CO), DHT11 (temperature & humidity), and MQ-4 (methane) with Arduino Uno to create a compact system capable of monitoring multiple environmental parameters simultaneously. This approach improves contextual understanding of pollution sources..

IoT-Enabled Data Transmission : Studies have incorporated ESP8266 Wi-Fi modules with Arduino Uno to transmit real-time air quality data to cloud platforms. This enables remote monitoring, data visualization, and predictive analytics, making the system suitable for smart city applications.

IV. METHODOLOGY

The methodology adopted for this project focuses on designing a stable, cost-effective, and energy-efficient mobility solution for disabled individuals. the process was divided into three key phases: design concept, material selection, and fabrication.

A. System Design

The system is designed to monitor air quality parameters using different sensors connected to a microcontroller. It focuses on measuring harmful gases and particulate matter present in the environment., .

B. Sensor Selection

Appropriate sensors are selected to detect air pollutants such as:

Gas sensors (for CO, CO_2, NO_2, etc.) Dust or particulate matter sensor (PM2.5, PM10) Temperature and humidity sensor (for accuracy compensation). Sensors continuously collect real-time air quality data from the surrounding environment. The analog or digital signals from sensors are sent to the microcontroller.

C. Communication Module

The processed data is transmitted wirelessly using Wi-Fi, Bluetooth, or GSM to a cloud platform or local server for storage and monitoring

V. WORKING

WORKING PRINCIPLE:

Air quality sensors continuously detect pollutants present in the surrounding environment. Gas sensors measure harmful gases such as carbon monoxide (CO), carbon dioxide (CO_2), and nitrogen dioxide (NO_2), while dust sensors measure particulate matter like PM2.5 and PM10.

The sensors generate analog or digital signals based on the concentration of pollutants. These signals are sent to a microcontroller.

The microcontroller processes the sensor data, converts it into pollutant concentration values, and compares them with standard air quality limits.

Based on the measured values, the system calculates the Air Quality Index (AQI), which indicates the level of air pollution and its impact on health.

The air quality information and AQI values are displayed on an LCD, OLED, or mobile application for easy monitoring.

The system transmits real-time air quality data to a cloud server or monitoring platform using Wi-Fi, GSM, or Bluetooth.

If air quality exceeds safe levels, the system triggers alerts such as buzzer alarms, SMS notifications, or app alerts.

The system operates continuously to provide real-time air quality monitoring and historical data for analysis.

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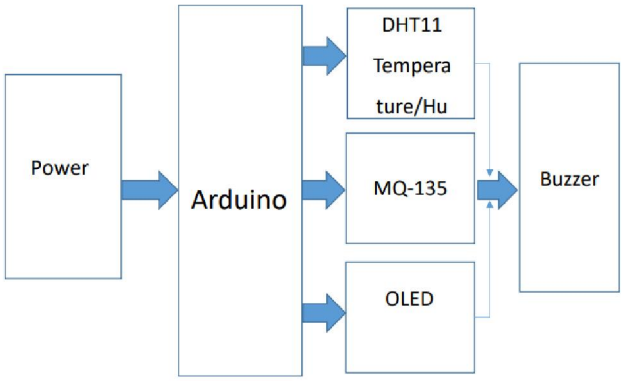

BLOCK DIAGRAM

COMPONENTS USED

- ➢ ARDUINO UNO ATmega328P
- ➢ DHT11 Temperature/HumiditySensor
- ➢ MQ-135 Gas Sensor
- ➢ POWER SUPPLY UNIT
- ➢ LCD DISPLAY | OLED Display (128*64)
- ➢ BUZZER
- ➢ BREADBOARD & JUMPER WIRES Solar Panel

VI. COMPONENTS DESCRIPTION

1. Gas Levels: The MQ-135 sensor detects multiple gases, including: Ammonia (NH3) Nitrogen Oxides (NOx) Carbon Dioxide (CO2) Benzene Smoke Alcohol Vapors The sensor outputs analog signals corresponding to the concentration of these gases, which the Arduino processes to determine air quality levels. 2. Air Quality Index (AQI): The MQ-135 sensor's readings are mapped to AQI categories such as "Good," "Poor," "Very Bad," or "Toxic," based on predefined thresholds. This provides a simplified representation of air pollution levels. 3. Temperature and Humidity: The DHT11 sensor measures: Temperature in degrees Celsius. Humidity as a percentage. These environmental factors are essential for understanding air quality in context, as they influence pollutant behavior and human comfort.

➢ Sensor Data Collection: The system uses MQ-135 Gas Sensor & DHT11 Sensor which continuously sense atmospheric conditions and send signals to the Arduino..

➢ Signal Processing by Arduino UNO: The Arduino UNO reads both analog and digital inputs received from both sensors & converts them into meaningful air-quality data, and processes them using programmed algorithms.

➢ Data Interpretation: The agitator motor mixes Materials A and B for 10 sec ensuring a consistent mixture. The Arduino compares sensor readings with predefined threshold values. It calculates: Air Quality Index (Approx. PPM from MQ-135), Temperature (°C), Humidity (%) (Based on these values, the system determines whether the air quality is Good, Moderate, or Poor.)

➢ Displaying Information on OLED: The processed data is sent to the 128×64 OLED Display

VII. ADVANTAGES

• Real-Time Monitoring: Provides immediate data on pollutant levels, enabling quick response to hazardous conditions . • Improved Public Health: Helps identify and mitigate exposure to harmful pollutants, reducing the risk of respiratory and cardiovascular diseases.

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• Data-Driven Decision Making: Assists policymakers and environmental agencies in creating effective regulations and control strategies based on accurate data.
• Early Warning System: Alerts communities and authorities during pollution spikes, allowing preventive actions such as traffic restrictions or health advisories

VIII. LIMITATIONS

An Air Quality Monitoring System (AQMS) has several limitations. The accuracy of the system depends heavily on the quality of sensors used, and low-cost sensors may produce inaccurate readings and require frequent calibration. Environmental factors such as temperature, humidity, and weather conditions can affect sensor performance and lead to measurement errors..

IX. CONCLUSION

The study on the Air Quality Monitoring System highlights the critical role of real-time monitoring in assessing and improving air quality. By leveraging advanced sensor technology, data analytics, and artificial intelligence, such systems provide valuable insights into pollutant levels, enabling proactive measures to mitigate environmental and health risks. The research findings demonstrate the effectiveness of these systems in detecting air pollutants, predicting trends, and aiding policymakers in implementing necessary regulations. Despite technological advancements, challenges such as data accuracy, sensor calibration, and accessibility remain key considerations. Future research should focus on improving sensor precision, expanding monitoring networks, and integrating AI-driven predictive models for more robust air quality management.

X. FUTURE SCOPE

The development of Air Quality Monitoring Systems (AQMS) is an evolving field with significant potential for future advancements. As technology progresses, several areas can be explored to enhance the efficiency, accuracy, and accessibility of AQMS: 1. Integration with Artificial Intelligence (AI) and Machine Learning (ML): Future research can focus on improving predictive modeling using advanced AI and ML algorithms to forecast air pollution trends with higher accuracy. These models can help in early warning systems and proactive decision-making for pollution control. 2. Expansion of Sensor Capabilities: The development of more sensitive and durable low-cost sensors can improve the accuracy and range of pollutant detection, including volatile organic compounds (VOCs) and greenhouse gases like methane (CH_4) and ozone (O_3).

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