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RESEARCH ARTICLE

Smart Environment Monitoring: Air Quality Index System

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ABSTRACT
The IoT-Based Air and Gas Quality Monitoring System uses an ESP32 microcontroller integrated with DHT11, MQ2, and MQ135 sensors to monitor temperature, humidity, and harmful gases in real time. It detects pollutants such as carbon monoxide, methane, ammonia, and smoke to assess air quality levels. The system displays data on an I2C 16×2 LCD for immediate monitoring. It also sends SMS alerts via a GSM module when gas levels exceed safe limits. Using Wi-Fi, it connects to cloud platforms like ThingSpeak or Blynk for remote access and data visualization, making it an efficient and cost-effective safety solution.

Keywords: *IoT, ESP32, Air Quality Monitoring, Gas Detection.*

INTRODUCTION

The Pre-Historic Life of Chandel/Tengnoupal Naga People:

In recent years, air pollution has become one of the most critical environmental challenges due to rapid urbanization, industrialization, and population growth. The increasing concentration of harmful gases such as carbon monoxide (CO), methane (CH_4), ammonia (NH_3), benzene, and smoke poses serious threats to public health and environmental stability.Traditional air monitoring systems are often expensive, bulky, and region-specific, limiting their use in small-scale or individual applications.Hence, there is a growing need for a low-cost, portable, and IoT-enabled system capable of providing continuous and real-time air quality analysis.The IoT-based Air and Gas Quality Monitoring System presented in this project addresses this issue by integrating ESP32, DHT11, MQ2, and MQ135 sensors. The ESP32 microcontroller acts as the core processing unit, collecting and analyzing sensor data related to temperature, humidity, and gas concentration. The results are displayed on an I2C-based 16×2 LCD, and in case of hazardous readings, an SMS alert is sent to users through a GSM module. Furthermore, the system utilizes ESP32's built-in Wi-Fi for cloud-based data logging and remote access through a mobile or web interface.

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This project not only provides real-time environmental insights but also contributes to smart city initiatives, pollution management, and industrial safety applications. Its modular design, affordability, and energy efficiency make it suitable for deployment in households, laboratories, industries, and urban environments, promoting better air quality awareness and proactive safety measures.

Air pollution and hazardous gas exposure have become critical concerns due to rapid industrialization and urbanization, posing serious risks to human health and the environment. Continuous monitoring of air quality is essential to detect harmful pollutants and ensure safety in both indoor and outdoor environments.

This research presents an IoT-Based Air and Gas Quality Monitoring System that utilizes an ESP32 microcontroller integrated with DHT11, MQ2, and MQ135 sensors to measure temperature, humidity, and detect toxic gases such as carbon monoxide, methane, ammonia, and smoke in real time.

The system processes sensor data to assess air quality levels, displays the information locally, and transmits it to cloud platforms for remote monitoring and analysis. Additionally, a GSM module is incorporated to provide instant alerts when pollutant levels exceed safe thresholds. The proposed system is cost-effective, energy-efficient, and suitable for applications in residential, industrial, and urban environments, contributing to improved environmental monitoring, early hazard detection, and the development of smart and sustainable cities.

2. Literature Survey

With the rise of urbanization and industrial development, air pollution has become a major global concern affecting human health and environmental balance. The emission of toxic gases such as carbon monoxide (CO), methane (CH_4), ammonia (NH_3), benzene, and smoke contributes to respiratory diseases and climate degradation. Traditional air monitoring systems are costly, complex, and mostly limited to industrial or government sectors, making them inaccessible for public or domestic use.

The proposed IoT-Based Air and Gas Quality Monitoring System aims to address this issue through a low-cost, portable, and real-time monitoring solution. Using the ESP32 microcontroller integrated with DHT11, MQ2, and MQ135 sensors, the system continuously measures environmental parameters and notifies users via LCD display, SMS alerts, and cloud dashboards. The combination of IoT and sensor technology enables smarter, faster, and more efficient air quality monitoring, contributing to safer living and working environments.

Existing air and gas monitoring systems are typically stationary, expensive, and complex to operate. They require manual supervision, lack wireless communication, and cannot send real-time alerts to users when gas levels exceed safe thresholds. These systems are often limited to industrial areas or government monitoring stations, making them unsuitable for small-scale or personal applications.

High Cost and Limited Accessibility:
Traditional air monitoring systems are expensive, bulky, and mainly used in industrial or government facilities, making them unsuitable for small-scale or personal use.

Lack of Real-Time Alerts and Automation:
Existing systems require manual monitoring and do not provide instant notifications when gas levels exceed safe limits, leading to delayed responses in emergencies.

No Wireless or Cloud Connectivity:
Most conventional systems lack Wi-Fi or IoT integration, preventing remote access, continuous data storage, and real-time visualization of environmental conditions.

Advancements in Internet of Things (IoT), wireless communication, and sensor technology have revolutionized environmental monitoring. The ESP32 microcontroller now provides built-in Wi-Fi and Bluetooth capabilities, enabling seamless data transmission to cloud platforms like ThingSpeak and Blynk. Compact sensors such as DHT11, MQ2, and MQ135 offer accurate measurement of temperature, humidity, and gas concentrations at a fraction of the cost of traditional equipment.Integration of GSM modules allows SMS alerts for real-time hazard notifications, even in areas without internet connectivity. Cloud integration enables remote data access, visualization, and historical trend analysis. These technological improvements make modern systems more energy-efficient, scalable, and user-friendly, suitable for deployment in homes, laboratories, and smart city infrastructures.

Recent papers such as Jain and Joshi (2024) [6] highlighted the growing relevance of Cloud-Native HR Solutions that provide seamless scalability and integration with communication tools like Slack or Microsoft Teams. The Smart Leave Scheduling Portal aligns with this trend by providing optional integration with email and calendar services for better institutional coordination.

From the above studies, it is evident that while several leave management systems exist, most of them focus on automation rather than intelligent scheduling and smart validation. Few provide comprehensive transparency, real-time analytics, and scalability required in academic institutions where multiple departments and hierarchical approvals exist.

Table1. Literature Review of IoT-Based Air Quality Monitoring Systems.

Author	Year	Title	Technology Used
Sharma et al.	2020	IoT-Based Air Quality Monitoring System	Arduino, MQ Sensors, Wi-Fi

Kumar & Singh	2021	Smart Gas Detection and Alert System	ESP8266, MQ2 Sensor, GSM
Patel et al.	2019	Environmental Monitoring using IoT	Raspberry Pi, DHT11, Cloud
Reddy et al.	2022	Air Pollution Monitoring System	ESP32, MQ135, ThingSpeak
Author	**Year**	**Title**	**Technology Used**
Sharma et al.	2020	IoT-Based Air Quality Monitoring System	Arduino, MQ Sensors, Wi-Fi
Kumar & Singh	2021	Smart Gas Detection and Alert System	ESP8266, MQ2 Sensor, GSM
Patel et al.	2019	Environmental Monitoring using IoT	Raspberry Pi, DHT11, Cloud
Reddy et al.	2022	Air Pollution Monitoring System	ESP32, MQ135, ThingSpeak

3. Methodology
The system uses an ESP32 microcontroller to collect data from DHT11, MQ2, and MQ135 sensors,

3.1 System Overview
- The system provides real-time detection of harmful gases and environmental conditions. This helps users take immediate action to ensure safety.

4. Implementation
The implementation of the IoT-Based Air and Gas Quality Monitoring System involves the integration of hardware and software components to achieve real-time air quality detection, data processing, and alert generation. The system is built around the ESP32 microcontroller, which serves as the core controller for managing sensors, display, communication modules, and cloud connectivity. The implementation process includes hardware setup, software programming, data communication, and testing to ensure accurate and reliable monitoring.

4.1 Hardware Setup
ESP32 Microcontroller Setup:
- The ESP32 is programmed using the Arduino IDE and acts as the central unit. It reads data from sensors, processes it, and sends the output to both the LCD and communication modules
- DHT11 Sensor measures temperature and humidity
- MQ2 Sensor detects gases like methane, propane, and smoke.
- MQ135 Sensor identifies air pollutants such as CO_2, ammonia, and benzene.

LCD Display Connection:
- A 16×2 I2C-based LCD module is connected to the ESP32 to display real-time readings of temperature, humidity, and gas levels for user reference.

GSM Module Integration:
The GSM module is interfaced with the ESP32 via UART communication.

4.2 Testing and Calibration
1. Sensor Calibration: Each gas sensor (MQ2, MQ135) is calibrated in a clean air environment to ensure accurate readings.
2. Threshold Testing: The system is tested under simulated pollution and smoke conditions to verify the alert mechanism.
3. Cloud Verification: Data uploads are verified on ThingSpeak to confirm stable Wi-Fi communication and real-time graph plotting.
4. SMS Alerts: GSM module successfully delivers SMS notifications within seconds of threshold breach.

4.3 Module Development
1. Sensor Module
2. Processing Module
3. Display Module
4. Communication Module
5. Cloud Module
6. Alert Module

4.4 Database Design
- Data Collection
- Data Storage
- Data Structure
- Timestamp Management
- Data Visualization
- Data Analysis

4.5 Integration and Testing
1. Module Integration: All hardware components including sensors, ESP32, LCD, GSM, and Wi-Fi are connected and configured. This ensures proper communication between modules.
2. System Integration: Software and hardware are combined to function as a complete system. This verifies end-to-end operation.
3. Unit Testing: Individual modules such as sensors and communication units are tested separately. This helps identify and fix component-level issues.
4. Functional Testing: The system is tested to ensure it performs required tasks like data collection, display, and alert generation. This confirms correct functionality.

5. Performance Testing: The system is evaluated for response time and accuracy. This ensures reliable real-time monitoring.
6. Alert Testing: SMS alerts are tested by simulating high gas levels. This ensures timely notifications are sent.
7. Cloud Testing: Data transmission to cloud platforms is verified. This ensures proper data logging and remote monitoring.

4.6 Deployment

- System Setup: The hardware components are assembled and installed in the required environment. This ensures proper placement for accurate monitoring.
- Configuration: The ESP32, sensors, GSM module, and Wi-Fi settings are configured. This enables smooth communication and data transmission.
- Installation Environment: The system is deployed in areas such as homes, industries, or laboratories. This ensures effective air quality monitoring in real conditions.
- Network Deployment: The device is connected to cloud platforms for remote access. This allows users to monitor data from anywhere.
- Testing After Deployment: The system is tested in the actual environment to verify performance. This ensures reliability and accuracy.
- Maintenance: Regular checks and calibration of sensors are performed. This helps maintain long-term efficiency and accuracy.

4.7 Results

Fig.2 Message

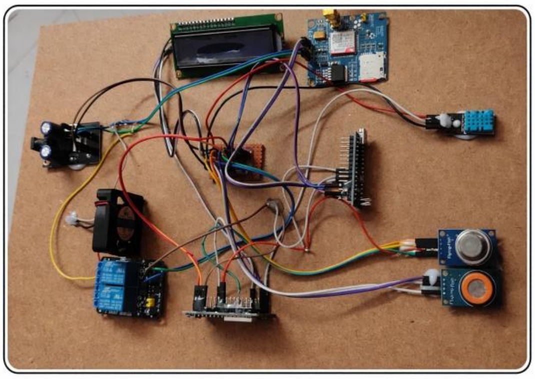

Fig.3 Tool Kit

The system successfully monitored temperature, humidity, and gas levels in real time. It provided accurate and consistent environmental data.
Harmful gases such as carbon monoxide, methane, and smoke were effectively detected. The system responded quickly to changes in air quality.
The LCD display showed real-time readings clearly for local monitoring. This helped users easily understand environmental conditions.
SMS alerts were successfully sent when gas levels exceeded safe thresholds. This ensured timely warnings and improved safety.
Data was transmitted to cloud platforms without interruption. This enabled remote monitoring and data visualization.
The system demonstrated reliable performance with low power consumption. It proved to be efficient, cost-effective, and suitable for real-world applications.

5. Conclusion

The IoT-Based Air and Gas Quality Monitoring System is an innovative, smart solution designed to continuously measure and analyze environmental conditions such as temperature, humidity, and gas concentrations in real time. With the increasing concerns about pollution, industrial gas leaks, and deteriorating air quality, this project provides a low-cost, energy-efficient, and portable monitoring system that can be easily implemented in homes, laboratories, industries, and smart cities. The system utilizes the ESP32 microcontroller as the central processing unit, integrated with DHT11, MQ2, and MQ135 sensors to detect various atmospheric parameters. It displays live readings on an I2C-based LCD, transmits the data to cloud platforms using Wi-Fi, and sends SMS alerts through a GSM module when pollutant levels exceed safe thresholds .The implementation of the system involves both hardware integration and software programming. The DHT11 sensor records temperature and humidity, while the MQ2 and MQ135 sensors detect harmful gases such as carbon monoxide (CO), methane (CH_4), ammonia (NH_3), benzene, and smoke. The ESP32 collects this data, processes it, and displays the results locally and remotely. The software was developed using Arduino IDE, incorporating libraries for sensor communication, LCD interfacing, Wi-Fi connection, and GSM communication. Cloud connectivity via platforms like ThingSpeak and Blynk enables real-time remote monitoring and long-term data visualization, allowing users to track environmental changes effectively.During the testing phase, the system was evaluated for functionality, reliability, and accuracy. All sensors were calibrated to ensure precise readings, and the GSM and Wi-Fi modules were verified for stable data communication. The system successfully detected changes in gas concentrations, sent timely alerts via SMS, and uploaded data to the cloud for visualization. Real-time readings were displayed clearly on the LCD, demonstrating consistent performance. The project proved capable of providing accurate, real-time environmental insights and responding quickly to potential hazards, fulfilling its intended objectives. This IoT-based design stands out for its simplicity, scalability, and affordability. Unlike traditional air quality monitoring systems, which are expensive, complex, and location-dependent, this system provides real-time, automated data collection and analysis accessible from anywhere. The low power consumption and compact design make it suitable for a wide range of applications — from household safety to industrial pollution control. Its modular architecture also allows future expansion, such as integrating additional sensors, solar power, machine learning algorithms, or mobile app connectivity for predictive analytics and advanced air quality forecasting. In summary, the IoT-Based Air and Gas Quality Monitoring System successfully demonstrates the integration of sensor technology, IoT connectivity, and automation to create a reliable environmental monitoring solution. It bridges the gap between traditional air quality measurement tools and modern smart technologies, providing users with instant awareness and control over their surroundings. The project emphasizes the importance of technology-driven solutions in promoting sustainable living, environmental protection, and public safety. Through this implementation, the system proves to be a practical, efficient, and impactful innovation contributing toward the development of smart, sustainable, and pollution-free communities.

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