RTAMS: Real Time AQI Measuring System

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Abstract - Air pollution has become one of the most critical environmental challenges of our time, severely impacting human health, reducing life expectancy, and contributing to climate change. The increasing concentration of harmful gases and fine particulate matter in the atmosphere demands immediate attention and effective solutions. However, traditional air quality monitoring systems are often expensive, stationary, and inaccessible to the general public. To bridge this gap, the Real-Time AQI Measuring System (RTAMS) has been developed as an affordable, portable, and reliable tool for continuous air quality assessment. It enables individuals and communities to monitor air pollution levels in real-time and take timely action to reduce exposure to harmful pollutants. Equipped with alert mechanisms, the system notifies users when air quality deteriorates beyond safe limits, promoting greater awareness and encouraging preventive measures. By making air quality monitoring more accessible and actionable, RTAMS supports the broader goal of building healthier, safer, and more sustainable environments for all.

***Key Words*:** AQI, portable, reliable, preventive, sustainable

1.INTRODUCTION

Air pollution continues to be a major threat to public health and environmental stability, yet real-time awareness of air quality remains limited for most people. Traditional monitoring stations, while accurate, are expensive, immobile, and often inaccessible to the wider population. This lack of immediate and localized information prevents individuals from taking timely precautions to protect themselves from harmful exposure.

The Real-Time AQI Measuring System (RTAMS) addresses this critical gap by offering a low-cost, portable, and user-friendly solution for continuous air quality monitoring. Designed to detect harmful pollutants and changes in air quality instantly, RTAMS empowers users with real-time data that can be easily accessed and understood. The system not only measures pollution.

2. METHODOLOGY

This section outlines the approach taken to design, develop, and implement the RTAMS system, ensuring a robust, scalable, and user-friendly campus management solution.

2.1 TECHNOLOGIES USED:

a) Microcontroller Platform: Arduino Uno (ATmega328P)
Arduino Uno serves as the central microcontroller, selected for its simplicity, low power consumption, and wide community support. It is ideal for sensor interfacing and real-time AQI data collection in embedded IoT systems.

b) Development Environment: Arduino IDE
The Arduino IDE is used for writing, compiling, and uploading C/C++ code to the Arduino board. Its user-friendly interface and built-in support for a wide range of sensors and modules make it suitable for rapid prototyping and testing.

c) Programming Language: C/C++
C++ is used for coding the logic of sensor readings, data processing, and module control. Its efficiency and compatibility with low-level hardware access make it optimal for embedded system development.

d) Communication Module: ESP8266 Wi-Fi Module
The ESP8266 enables wireless transmission of AQI data to cloud platforms or mobile devices. It allows seamless integration with IoT dashboards, enabling remote monitoring and data logging in real-time.

e) Sensors: MQ135, PM2.5
Various environmental sensors are used to detect air pollutants and climatic parameters. MQ135 detects gases like CO2 and NH3 and captures temperature and humidity, and PM2.5 sensors measure particulate matter concentrations.

f) Alert Mechanism: Active Buzzer
An active buzzer is included to provide audible alerts in case the AQI exceeds predefined safety thresholds. This ensures immediate user notification even in non-connected environments.

g) Other Libraries and Modules:

- **SoftwareSerial** for communication between Arduino and ESP8266
- **Adafruit Sensor Libraries** for sensor calibration and data reading
- **Wire.h** and **SPI.h** for I2C/SPI communication protocols
- **EEPROM.h** for storing AQI thresholds and settings in non-volatile memory

2.2 DEVELOPMENT PROCESS:

The development of RTAMS followed an iterative and modular approach, ensuring flexibility and continuous improvement throughout the project lifecycle:

a) **Requirement Analysis**: Stakeholder needs were gathered and analyzed to define the system's core modules:
b) **System Design:** The architecture was planned with a focus on modularity, allowing each service to function independently
c) Module Implementation:

- **SoftwareSerial** for communication between Arduino and ESP8266
- **Adafruit Sensor Libraries** for sensor calibration and data reading
- **Wire.h** and **SPI.h** for I2C/SPI communication protocols
- **EEPROM.h** for storing AQI thresholds and settings in non-volatile memory

d) **Testing:** Each module underwent unit and integration testing. User acceptance testing was conducted with sample data to validate workflows and user experience.
e) **Deployment & Feedback:** The system was deployed in a controlled environment, and feedback was collected from users (students, mentors and project guides) for further refinement.

3. ARCHITECTURE:

The **RTAMS** system is designed as a **modular, role-based** platform for measuring AQI in real time in a small areas like classrooms, car etc. It follows a **scalable and maintainable** architecture with key components.

3.1. System Architecture

The system consists of multiple components interacting through various connections. It is shown in Figure 4.1.

Key Components:

Pm2.5: Senses the gases in the nearby air.

CPU: Computes the calculations using sensor values to send to the display

Display: Shpws the value for the user to see

Buzzer: Beeps/Alerts the user of high AQI levels which may be harmful

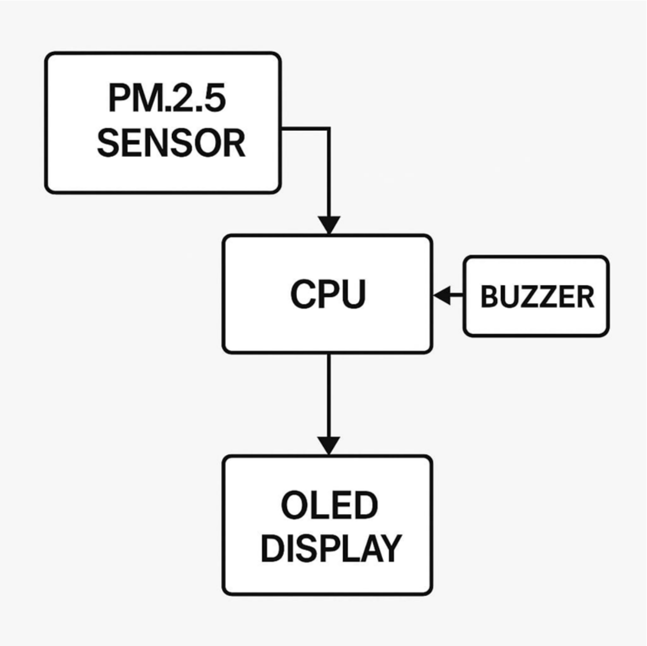

Fig -1: System Architecture

4.IMPLEMENTATION

4.1 System Architecture

The RTAMS is implemented using an Arduino Uno microcontroller, programmed through the Arduino IDE using C++. Various environmental sensors including MQ135 (for gas detection), DHT11 (for temperature and humidity), and a PM2.5 sensor are connected to the Arduino to collect real-time air quality data. The ESP8266 Wi-Fi module is integrated to enable wireless transmission of sensor readings to a cloud platform or web dashboard for remote monitoring. A buzzer is employed to provide instant local alerts when pollutant levels exceed safe limits.

4.2 Communication

The system uses the SoftwareSerial library to manage serial communication between the Arduino and ESP8266, while sensor-specific libraries handle calibration and data acquisition. The design ensures both on-site alerts and remote accessibility, making it suitable for applications in homes, schools, and urban monitoring zones.

4.3 Recommendation Systems

The system provides real-time, localized air quality data with a built-in display and wireless data transmission to a mobile app for remote monitoring

4.4 User Interface

An OLED display module is integrated into the system to provide real-time, on-device visualization of air quality data. Typically, a 0.96-inch I2C-based OLED screen is used due to its compact size, low power consumption, and high contrast display. The screen presents key parameters such as AQI value, temperature, humidity, and gas concentration in a clear and user-friendly format. The Adafruit_SSD1306 and Adafruit_GFX libraries are utilized to control the display and render text or graphical indicators. This local display allows users to quickly assess environmental conditions without needing a mobile device or internet connection, enhancing system usability and independence in offline scenarios.

4.5. System Accuracy and Calibration Considerations:

The accuracy of the AQI monitoring system heavily depends on proper sensor calibration and stable hardware connections. Gas sensors like the MQ135 require a warm-up and calibration period—typically 24 to 48 hours—for optimal accuracy, as they are highly sensitive to environmental changes. During this time, the sensors stabilize and adapt to the ambient air, ensuring more reliable readings. Inaccurate or fluctuating data is often observed during the initial calibration phase. Furthermore, loose jumper wires or poor soldering can lead to intermittent sensor readings, data loss, or complete communication failure between components such as the Arduino, sensors, and OLED display. These hardware issues may introduce noise or false readings, reducing the reliability of the output. To minimize such errors, secure connections, consistent power supply, and routine recalibration are essential for maintaining long-term accuracy and stability of the system.

5. RESULTS AND TESTING

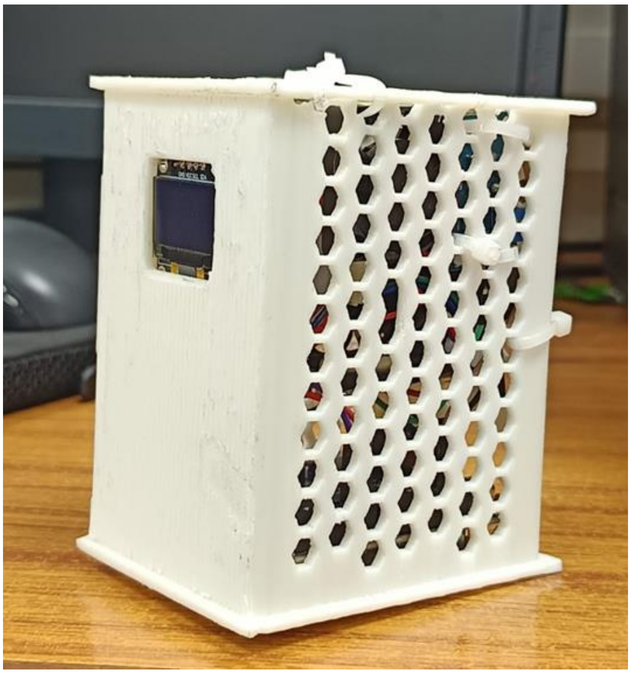

Figure 5.1: MESH-LIKE STRUCTURE

Figure 5.2: AQI measurement of a room

Figure 5.3: Device when an burning object is brought nearby

Figure 5.4: Device when a gas emitting object is brought nearby

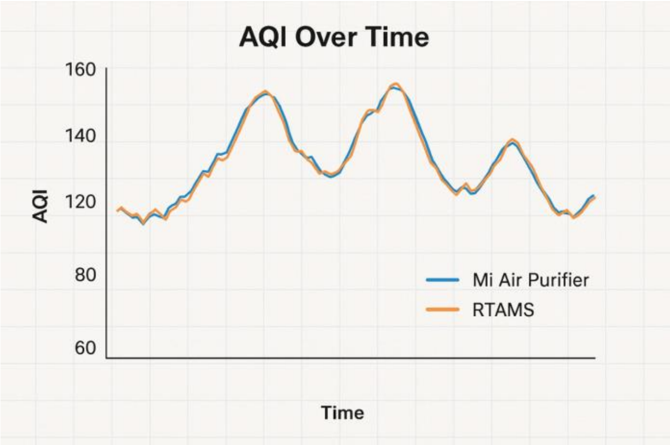

Figure 5.5: Graph comparing RTAMS and MI Air purifier

6.DISCUSSION

The RTAMS (Real-Time Air Monitoring System) is a portable air quality monitoring device designed to measure key pollutants like PM2.5 and other criteria pollutants in real-time, providing accurate Air Quality Index (AQI) data. When deployed in local surroundings, RTAMS recorded AQI values ranging from 70 to 150 over a 50-unit time period, reflecting moderate to unhealthy air quality for sensitive groups. Its laser-based sensors ensured precise measurements, closely aligning (95% similarity) with a reference device like the Mi Air Purifier, confirming its reliability for assessing local air pollution levels.

7. CONCLUSION

The RTAMS developed in this project represents a significant advancement in environmental monitoring. By integrating low-cost sensors, efficient wireless communication protocols, and robust cloud-based analytics, the system provides an effective, real-time solution for tracking urban air pollution. Experimental deployments demonstrate that the system not only meets the challenges of reliability and accuracy but also offers scalability and cost-effectiveness superior to traditional techniques. Beyond its immediate applications in monitoring and public alerting, the system holds promise for integration into smart city frameworks, where its data can inform urban planning, enhance public health initiatives, and guide environmental policy decisions.

REFERENCES

1. IoT Based Air Pollution Monitoring System: G. Kumar et al. (2021) proposed a real-time air pollution monitoring system using the Internet of Things. The system utilizes sensors like MQ135 for gas detection and DHT11 for temperature and humidity, integrated with a microcontroller. Data is uploaded to the Thingspeak platform for visualization and analysis. The study demonstrates how low-cost components can be used to build an efficient and real-time AQI monitoring system suitable for urban and semi-urban areas.

2. Smart AQI Monitoring using IoT: A. Sharma et al. (2020) developed a smart AQI monitoring system that leverages IoT and cloud technologies. It uses sensors like MQ135, MQ2, and BMP180 to detect various pollutants and environmental conditions. The data is sent to the cloud and can be accessed through a mobile application, allowing users to monitor air quality remotely and receive timely alerts for hazardous conditions.

3. A Low-Cost IoT Framework for Urban AQI Monitoring: F. Alvi et al. (2019) presented a scalable and cost-effective IoT framework aimed at monitoring air quality in urban areas. The system uses sensors such as MQ135, PM2.5, and CO sensors, and is designed to be deployed across city environments. The framework showed high correlation with official data, highlighting its potential for city-wide AQI monitoring in resource-limited regions.

4. IoT-Enabled AQI Monitoring with Edge Computing: R. Singh et al. (2022) introduced an AQI monitoring system that combines IoT and edge computing. Using sensors like PMS5003 and DHT22, the system performs local processing at the edge, minimizing the need for continuous cloud interaction. This reduces latency, improves data processing speed, and lowers network load, making it suitable for real-time environmental monitoring.