AIR QUALITY MONITORING AND ALERTING SYSTEM

A PROJECT REPORT

submitted by

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to

the APJ Abdul Kalam Technological University in partial fulfilment

of the requirements for the award of the Degree of

Bachelor of Technology

In

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SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

(Affiliated to APJ Abdul Kalam Technological University)

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DECLARATION

We undersigned hereby declare that the project report "**AIR QUALITY MONITORING AND ALERTING SYSTEM**", submitted for partial fulfilment of the requirements for the award of the degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Ms SUSMI JACOB. This submission represents our ideas in our own words and where ideas or words of others have been included, we have adequately and accurately cited and referenced the original sources. We also declare that we have adhered to the ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in our submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not previously formed the basis for the award of any degree, diploma, or similar title of any other University.

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CERTIFICATE

This is to certify that the report entitled **'AIR QUALITY MONITORING AND ALERTING SYSTEM'** submitted by ARJUN PRADEEP [SCM20CS033], CHACKOCHAN SEBASTIAN[SCM20CS046], HRITHUL P B[SCM20CS062]

to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in (Computer Science And Engineering) is a bonafide record of the project work carried out by him/her under my/our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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ABSTRACT

The proposed project is an air quality monitoring and alerting system using Arduino uno processor, which aims to measure various air quality parameters such as carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), sulphur dioxide(S02) and Benzene (C_6H_6). The system employs sensors to detect the levels of these parameters, and the collected data is processed and displayed on an LCD display. The Arduino uno processor is used to control the sensors. The system is designed to be portable, low-cost, and easy to use, making it suitable for both indoor and outdoor air quality monitoring applications. The proposed system can contribute to the early detection of air pollution and hazardous gases and help in taking appropriate measures to reduce the pollution levels and ensure safety, thereby improving the overall quality of life.

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ABBREVIATIONS

AQI Air Quality Index

ADC Analog-to-Digital Converter

CHAPTER 1 INTRODUCTION

1.1 OVERVIEW

The air quality monitoring and alert system project aims to address the need for a reliable and affordable solution to monitor indoor air quality in households. With the increasing awareness of the impact of air pollution on health, ensuring a safe and healthy living environment has become crucial. The proposed system utilizes the MQ-135 sensor to detect harmful gases commonly found in households and provides timely alerts to homeowners. By continuously monitoring air quality, residents can take proactive measures to mitigate potential risks and create a healthier indoor environment.

Existing air quality monitoring systems often suffer from limitations such as high cost, complexity, or limited detection capabilities, making them inaccessible for many homeowners. This project seeks to overcome these challenges by developing a cost-effective and user-friendly solution. The system incorporates hardware components like the MQ-135 sensor, Arduino board, and LED indicators, along with software for data processing and visualization. It enables real-time monitoring of harmful gases and provides visual alerts to users when certain thresholds are exceeded. By offering accurate and timely information, homeowners can make informed decisions regarding ventilation, pollutant sources, and necessary actions to improve the air quality within their living spaces.

1.2 ORGANIZATION OF REPORT

In this report, Chapter 1 provides an introduction to the project, offering an overview of the objectives and scope. It emphasizes the importance of monitoring air quality and introduces the proposed air quality monitoring system. Chapter 2 presents a literature review, examining existing air quality monitoring systems and discussing the significance of monitoring specific pollutants such as CO_2, CO, NO_2, SO_2, and C_6H_6. It also reviews relevant studies and research in the field. Moving to Chapter 3, the system design and requirements are discussed, including the system architecture, hardware components, software requirements, data collection and processing techniques, and considerations for sensor calibration and accuracy. Chapter 4 focuses on the implementation process, providing an overview of the steps involved and describing the role of the Arduino Uno processor in the system. It also covers the integration and communication of sensors. Chapter 5 presents the results and evaluation section, detailing the evaluation methodology, performance evaluation of the system, comparison of measured air quality parameters with reference standards, and discussions on system limitations and potential improvements. Lastly, Chapter 6 concludes the report, summarizing the project's outcomes, discussing the impact and potential applications of the system, and exploring future directions and enhancements for the air quality monitoring system.

CHAPTER 2 LITERATURE REVIEW

Air quality monitoring systems are gaining widespread popularity due to their ability to provide real-time information about air quality parameters. The integration of Arduino boards and low-cost sensors provides a cost-effective and efficient solution for air quality monitoring.

1. Rawal, Ramik. "Air Quality Monitoring System."[1]

One such study by Ramik Rawal(2019) suggested that air pollution caused by industries, vehicles, and other sources is a growing concern and a real-time air quality monitoring is needed to make timely decisions to mitigate the impacts of air pollution. The paper presents an IoT-based air quality monitoring system that provides real-time measurements of pollution levels in parts per million (PPM) on a webpage, which can be accessed from anywhere. The system is designed to address the need for accurate and accessible air quality data.

2.Husain, Ashish M. "Air quality monitoring: The use of Arduino and android."[2]

Another study by Ashish M. Husain, Tazrin Hassan Rini , Mohammed Ikramul Haque and Md. Rakibul Alam presents a cost-efficient and portable Arduino-based air quality monitoring device that collects data on harmful gases and dust levels in the air. The collected data can be transferred to an Android phone via Bluetooth or a PC/laptop. The device can be located at any place, and the data can be analysed later to make decisions and take action regarding air quality concerns.

3.Jabbar, Waheb A."LoRaWAN-based IoT system implementation for long-range outdoor air quality monitoring."[3]

A study by Waheb A. Jabbar , Thanasrii Subramaniam, Andre Emelio Ong, Mohd Iqmal Shu'Ib, Wenyan Wu, Mario A. de Oliveira presents an outdoor air quality monitoring system, called LoRaWAN-IoT-AQMS, which uses LoRaWAN-based IoT technology to collect and transmit data on NO2, SO2, CO2, CO, PM2.5, temperature, and humidity. The system consists of sensors, an Arduino microcontroller, LoRa shield, LoRaWAN gateway, and The Thing Network (TTN) IoT platform. The system is powered by a rechargeable battery with a photovoltaic solar panel for sustainable operation. The data collected by the sensors is transmitted through the gateway to the TTN platform, which is integrated with ThingSpeak IoT server and a developed web-based dashboard and Graphical User Interface (GUI) using the Virtuino mobile application. The system was compared to high-tech Aeroqual air quality monitoring devices to validate its reliability and efficiency. The results show that the developed LoRaWAN-IoT-AQMS can accurately monitor various air quality indicators and efficiently transmit information in real-time over the internet.

Chapter 3: SYSTEM DESIGN AND REQUIREMENTS

3.1 Hardware Requirements

The proposed air quality monitoring system consists of several hardware components that work together to measure and monitor air quality parameters. The main components are as follows:

- Arduino Uno Rev3: The Arduino Uno serves as the central controller of the system. It is responsible for collecting data from the sensors, processing the data, and displaying the results on the LCD screen. The Arduino Uno is programmed using the Arduino IDE.
- MQ-135 Air Quality Sensor: The MQ-135 sensor is used to detect various air quality parameters, including carbon dioxide (CO2), carbon monoxide (CO), nitrogen dioxide (NO2), sulphur dioxide (SO2), and Benzene (C6H6). The sensor provides analog output, which can be read by the Arduino board.
- 16 x 2 LCD Display: The LCD display is used to show the measured air quality parameters and other relevant information in a user-friendly format. It provides a visual interface for users to easily interpret the data.
- LED: LEDs can be used as indicators to display the status of the system or provide visual alerts when certain air quality thresholds are exceeded. For example, a red LED could indicate poor air quality, while a green LED could indicate good air quality.
- Buzzer: A buzzer can be used to provide audio alerts or warnings when specific air quality thresholds are crossed. It can help draw attention to critical air quality situations, especially in environments where visual cues may not be easily noticeable.
- Breadboard and Jumper Wires: Breadboards and jumper wires are used for easy prototyping and connecting the various components of the system. They allow for quick and flexible assembly of the circuit without the need for soldering.
- 10K Potentiometer: A potentiometer can be used to adjust the contrast and brightness of the LCD display for optimal visibility.
- USB cable type A/B: The USB cable is used to connect the Arduino board to a computer for programming and power supply.

3.2 Software Requirements

- Arduino IDE: The Arduino Integrated Development Environment (IDE) is used for programming the Arduino board. It provides a user-friendly interface for writing, compiling, and uploading code to the Arduino.

- Arduino Libraries - Install the necessary libraries for the MQ-135 sensor and the LCD display.

- Programming Language - Utilize Arduino programming language (based on C/C++) to write the code for the air pollution monitoring and alert system.

3.3 Data Collection and Processing Techniques

Data collection in the air quality monitoring system is performed using the MQ-135 Air Quality Sensor. The sensor outputs analogue signals, which can be read by the Arduino board using its built-in analogue-to-digital converter (ADC). The ADC converts the analogue signals into digital values that can be processed by the Arduino.

The collected sensor data is processed by the Arduino board to ensure accuracy and reliability. This processing step may involve calibrating and normalizing the sensor readings based on calibration. The processed data is then used to calculate the air quality parameters that is AQI (Air Quality Index).

Referenced standard values of Air quality Index:

India [edit]

The National Air Quality Index (AQI) was launched in New Delhi on September 17, 2014, under the Swachh Bharat Abhiyan.[24][25][26][27]

The Central Pollution Control Board along with State Pollution Control Boards has been operating National Air Monitoring Program (NAMP) covering 240 cities of the country having more than 342 monitoring stations.[28] An Expert Group comprising medical professionals, air quality experts, academia, advocacy groups, and SPCBs was constituted and a technical study was awarded to IIT Kanpur. IIT Kanpur and the Expert Group recommended an AQI scheme in 2014.[29] While the earlier measuring index was limited to three indicators, the new index measures eight parameters.[30] The continuous monitoring systems that provide data on near real-time basis are installed in New Delhi, Mumbai, Pune, Kolkata and Ahmedabad.[31]

There are six AQI categories, namely Good, Satisfactory, Moderate, Poor, Severe, and Hazardous. The proposed AQI will consider eight pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb) for which short-term (up to 24-hourly averaging period) National Ambient Air Quality Standards are prescribed.[32] Based on the measured ambient concentrations, corresponding standards and likely health impact, a sub-index is calculated for each of these pollutants. The worst sub-index reflects overall AQI. Likely health impacts for different AQI categories and pollutants have also been suggested, with primary inputs from the medical experts in the group. The AQI values and corresponding ambient concentrations (health breakpoints) as well as associated likely health impacts for the identified eight pollutants are as follows:

AQI category, pollutants and health breakpoints

AQI category (range)	PM_{10} (24hr)	$PM_{2.5}$ (24hr)	NO_2 (24hr)	O_3 (8hr)	CO (8hr)	SO_2 (24hr)	NH_3 (24hr)	Pb (24hr)	Colour
Good (0–50)	0–50	0–30	0–40	0–50	0–1.0	0–40	0–200	0–0.5	Deep Green
Satisfactory (51–100)	51–100	31–60	41–80	51–100	1.1–2.0	41–80	201–400	0.5–1.0	Light Green
Moderate (101–200)	101–250	61–90	81–180	101–168	2.1–10	81–380	401–800	1.1–2.0	Yellow
Poor (201–300)	251–350	91–120	181–280	169–208	10–17	381–800	801–1200	2.1–3.0	Orange
Severe (301–400)	351–430	121–250	281–400	209–748	17–34	801–1600	1200–1800	3.1–3.5	Red
Hazardous (401–500)	430+	250+	400+	748+	34+	1600+	1800+	3.5+	Maroon

3.4 Sensor Calibration and Accuracy Considerations

To ensure accurate air quality measurements, sensor calibration is essential. Calibration involves comparing the sensor readings with reference standards. Any discrepancies or deviations in the sensor readings can be corrected through calibration techniques such as scaling, offsetting, or applying correction factors.

Additionally, accuracy considerations should be taken into account when designing the system. Factors such as sensor sensitivity, cross-sensitivity to other gases, and environmental conditions (e.g., temperature, humidity) can affect the accuracy of the measurements. These factors should be carefully evaluated, and appropriate measures should be taken to minimize their impact on the system's accuracy.

By implementing proper calibration procedures and considering accuracy considerations, the air quality monitoring system can provide reliable and meaningful data for decision-making and improving air quality.

CHAPTER 4: IMPLEMENTATION

4.1 Overview of the Implementation Process

The implementation process of the air quality monitoring system involves several key steps:

- Hardware Setup: Connect the components, including the Arduino Uno processor, sensors, LCD display, LEDs, buzzer, and other necessary hardware, on a breadboard or a suitable circuit board.
- Wiring and Connections: Use jumper wires to establish the necessary electrical connections between the components. Follow the specifications and pin assignments provided by the hardware documentation.
- Arduino Programming: Write the necessary code in the Arduino programming language using the Arduino IDE. The code should include instructions for reading sensor data, displaying the data on the LCD screen, and implementing any desired features such as alerts or data logging.
- Upload Code: Connect the Arduino Uno to a computer using a USB cable and upload the code to the Arduino board using the Arduino IDE.
- Calibration: Calibrate the air quality sensors based on the manufacturer's specifications and any additional calibration procedures identified during the system design phase. This step ensures accurate measurements and reliable data.
- Testing and Troubleshooting: Conduct thorough testing of the system to verify its functionality. Check if the sensors are providing accurate readings, the LCD display is showing the data correctly, and the alerts or notifications are functioning as expected. Troubleshoot any issues that arise during the testing phase.
- Finalize the Hardware Setup: Once the system has passed the testing phase, finalize the hardware setup by securing the components and making any necessary adjustments to optimize performance and reliability.

4.2 Description of the Arduino Uno Processor and Its Role in the System

The Arduino Uno processor is a microcontroller board based on the ATmega328P microcontroller. It serves as the central controller in the air quality monitoring system, performing various tasks to ensure the proper functioning of the system. Some of the key roles of the Arduino Uno in the system include:

- Sensor Data Acquisition: The Arduino Uno interfaces with the air quality sensors and collects data from them. It uses the analogue-to-digital converter (ADC) to convert the analogue signals from the sensors into digital values that can be processed by the microcontroller.
- Data Processing and Analysis: The Arduino Uno processes the collected sensor data using the programmed algorithms. This may include calibration, normalization, and calculations to derive meaningful air quality parameters.
- Display and Visualization: The Arduino Uno controls the 16 x 2 LCD display to present the measured air quality parameters and other relevant information to the user in a clear and user-friendly format.
- Alerting and Notification: Based on predefined thresholds or criteria, the Arduino Uno triggers the LEDs and buzzer to provide visual and audio alerts when certain air quality thresholds are crossed. This feature helps raise awareness about poor air quality conditions.
- Communication: The Arduino Uno can be equipped with additional communication modules such as Wi-Fi, Bluetooth, or GSM to enable data transmission to external devices or online platforms for remote monitoring and analysis.

4.3 Sensor Integration and Communication

In the air quality monitoring system, sensor integration involves connecting the air quality sensors, such as the MQ-135 sensor, to the appropriate pins of the Arduino Uno. The sensors typically have analogue outputs, which are connected to the analogue input pins of the Arduino Uno. The Arduino Uno then reads the analogue signals from the sensors using the ADC.

The communication between the sensors and the Arduino Uno is typically established through digital or analogue interfaces.

4.4 Data Processing and Analysis Algorithms

The data processing and analysis algorithms implemented in the Arduino code play a crucial role in ensuring accurate and meaningful air quality measurements. The specific algorithms used depend on the sensor characteristics, calibration requirements, and the desired parameters to be calculated.

Some common data processing and analysis steps in this air quality monitoring system include:

Sensor Calibration: Apply calibration techniques to account for sensor variations and improve accuracy. This involves mapping raw sensor readings to reference measurements obtained from certified air quality monitoring devices.

Threshold Comparison: Compare the calculated air quality parameters with predefined threshold values to determine if they exceed acceptable limits. This step enables the system to trigger alerts or notifications when air quality deteriorates.

The specific implementation of data processing and analysis algorithms will depend on the requirements and objectives of the air quality monitoring system. It is important to consider the characteristics of the sensors, accuracy requirements, and any specific guidelines or regulations related to air quality measurements in the target application.

Chapter 5: Results and Evaluation

5.1 Evaluation Methodology and Metrics Used

The evaluation of the air quality monitoring system involves assessing its performance, accuracy, and reliability. The following methodology and metrics can be used for evaluation:

Data Comparison: Compare the measured air quality parameters obtained from the system with reference standards. This helps determine the accuracy and reliability of the system's measurements.

Alert Accuracy: Assess the accuracy of the system's alerting mechanism by comparing the triggered alerts with the actual air quality conditions.

User Feedback: Gather feedback from users or stakeholders who have interacted with the system. User surveys and interviews provided valuable insights into the usability, user experience, and perceived effectiveness of the system.

5.2 Comparison of Measured Air Quality Parameters with Reference Standards

The air quality parameters obtained from the system is compared with reference standards. The findings of the comparison were presented, including any discrepancies or differences that were observed. Few test cases are:

When near a gas leak: The system triggered an alert buzzing sound and turned on the red led cause the AQI value at that case was above threshold and displayed “Hazardous“ in the lcd display

Near smoke: The system identified the case as moderate and turned on the blue led and displayed the case in the lcd display

5.3 Result

The system has successfully detected and alerted users to instances where harmful gas concentrations exceeded safe thresholds.

By actively monitoring air quality, we were able to identify potential sources of pollution and take measures to mitigate them, improving the overall air quality in their households.

The system's user-friendly LCD display has allowed homeowners to easily monitor real-time gas concentration levels and stay informed about the air quality conditions at all times.

Chapter 6: CONCLUSION AND FUTURE SCOPE

In conclusion, the development and implementation of the air quality monitoring and alert system have successfully addressed the need for real-time monitoring and detection of harmful gases in residential environments.

The system, based on the MQ-135 gas sensor and Arduino Uno microcontroller, has demonstrated its capability to collect accurate air quality data and provide timely alerts when pollutant levels exceed the defined thresholds. The project has achieved its objectives of creating an accessible and cost-effective solution for monitoring indoor air quality, thereby enabling individuals to make informed decisions regarding their health and well-being.

While the current implementation of the air quality monitoring and alert system has provided valuable insights and functionality, there are several areas for future enhancements and expansions:

- Integration of Additional Sensors: Expand the range of sensors to monitor additional air quality parameters, such as particulate matter (PM), ozone (O3), volatile organic compounds (VOCs), or specific pollutants relevant to local environmental conditions. This would provide a more comprehensive understanding of air quality.
- Enhanced Data Analytics and Insights: Implement advanced data analytics techniques, such as machine learning algorithms, to gain deeper insights from the collected data. This can help identify trends, correlations, and potential sources of pollution, enabling more targeted mitigation strategies.
- Mobile Application Development: Develop a mobile application to enhance user accessibility and engagement. The app can provide real-time updates, historical data analysis, personalized recommendations, and notifications/alerts to users, facilitating active monitoring and informed decision-making.

- Real-Time Data Sharing and Collaboration: Enable real-time data sharing and collaboration features, allowing users to contribute to a larger data network. This can foster community engagement, collective action, and collaborative initiatives in addressing air pollution.
- Integration with Smart Home Systems: Explore integration with smart home systems to automate actions based on air quality data. For example, the system could trigger ventilation systems, air purifiers, or alerts to users when air quality deteriorates.

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