IOT Enabled Air Quality Monitoring System

1st Prof. Anilkumar Ravjibhai Patel
Department Computer Science Engineering PIET
Vadodara, Gujarat
anilkumar.patel2986@paruluniversity.ac.in

2th Dr. Sanjay Agal
CSE-AI PIET
Vadodara, Gujarat
sanjayagal@gmail.com

3nd Eedara Venkata Ramana
CSE-AI PIET
Vadodara, Gujarat
210303124395@paruluniversity.ac.in

4rd Dasathwar Srinivas
CSE-AI PIET
Vadodara, Gujarat
210303124365@paruluniversity.ac.in

5th Yanamadala Nuthan Kumar
CSE-AI PIET
Vadodara, Gujarat
210303124111@paruluniversity.ac.in

6th Erani Sarvan Kumar
CSE-AI PIET
Vadodara, Gujarat
210303124401@paruluniversity.ac.in

***Abstract*—Pollution poses one of the most significant threats to our environment, with various types of pollution impacting the Earth's well-being. In the context of our project, we primarily address air pollution, which is a major concern. Air pollution is responsible for causing numerous health issues in both humans and animals, including respiratory problems. Polluted air contains a mixture of harmful gases such as CO2, CO, SO2, smoke, and benzene. To mitigate the effects of these pollutants, we must take measures like avoiding areas with high levels of polluted air. To implement these measures effectively, we require instruments to measure air quality. As a technical solution, we have chosen to develop an Air Quality Index (AQI) system based on the Internet of Things (IoT). This approach is cost-effective, decentralized, efficient, and portable, providing a significant improvement over the traditional method of using complex laboratory equipment, which is both costly and lacks portability. Our project focuses on implementing an AQI system using IoT technology, aiming to transfer data from sensors to an application or web server via the Internet. This technological advancement allows individuals to check air quality in their surroundings easily, offering valuable information for making decisions about their safety. For instance, while travelling in a car, users can quickly assess the air quality index, and if the particulate matter concentration exceeds 1000 ppm, they can identify the air as harmful. We plan to use an Arduino Uno microcontroller for this purpose, as it offers a suitable platform for programming in C and C++ and is supported by a thriving community and libraries.**

I. Introduction

Air pollution is a pressing global issue that adversely affects human health and the environment. With increasing industrialization and urbanization, monitoring air quality has become essential for ensuring safe living conditions. Traditional air quality monitoring systems are often expensive, stationary, and inaccessible to the general public. To address these challenges, we have developed an IoT-based Air Quality Monitoring System, which provides real-time air quality data with remote access capabilities.

Our system utilizes MQ135 and LM35 sensors to detect harmful gases and measure temperature, respectively. These sensors generate voltage outputs that correspond to the concentration levels of pollutants in the environment. The Arduino UNO microcontroller serves as the central processing unit, converting sensor data into PPM (Parts Per Million) values for an accurate assessment of air quality. The processed information is displayed on an LCD screen, providing users with instant insights.

To enhance accessibility and usability, we have integrated a Wi-Fi module, enabling wireless data transmission. This feature allows users to remotely monitor air quality via a dedicated web server, ensuring real-time data access from any location with internet connectivity. Additionally, we plan to develop an Android application, offering an intuitive interface for users to visualize, analyze, and interpret air quality metrics effortlessly.

By combining IoT technology, cloud-based data access, and mobile app integration, our system provides a cost-effective, scalable, and user-friendly solution for air pollution monitoring. This project holds significant potential for deployment in urban environments, industrial zones, and smart cities, contributing to pollution awareness and proactive health measures.

II. Literature Review

In this chapter, we present our comprehensive critical assessment and summarize the research papers that have been integral to our project. Our literature review encompasses a wide array of reference papers, delving into topics closely aligned with our project's objectives. In addition to the core features, we have also explored supplementary aspects that promise to enhance the accuracy and efficiency of our results. These additional facets encompass weather prediction, integration with an Android application, utilization of Raspberry Pi, incorporation of fuzzy logic, and adaptability for smart cities. Our exploration of these extended dimensions aligns with our pursuit of a more holistic and versatile approach to address the complexities of our project

"An IoT-based air pollution monitoring system for smart cities" by F. A. M Afsar and A. R. A Rahim. Published in the IEEE Access Journal in 2020. This paper proposes an air pollution monitoring system based on Internet of Things(IoT) Technology for smart cities.

"IoT Based Air Quality Monitoring System using Machine Learning Techniques" by K. V. K Rao, P.S Kumar, and D.K Saini. Published in the International Journal of Engineering And Advanced Technology in 2020. This paper mainly focuses on air quality monitoring systems Enabled by Internet Of Things technology and machine learning techniques.

"Design and implementation of an IoT Based Air Quality Monitoring System" by M. A. AI Heety and M. R. Kabir. Published in the IEEE Sensors journal in 2018. This paper outlines the development and implementation of an air quality monitoring system that leverages IoT technology.

A Comprehensive Review on IoT Based Air Pollution Monitoring System" by N.K. Singh and A.K. Srivastava. Published in the International Journal of Computer Science and Information Technology Research in 2017. This paper reviews various IoT-based air pollution monitoring systems, including their architecture, sensors, communication protocols, and data analysis techniques.

"Development of IoT Based Air Quality Monitoring System using Raspberry Pi" by R. Ahmad, S. H. Hussain, S. H. Shah(2020). This paper presents the development of an air quality monitoring system based on IoT technology utilizing a Raspberry Pi.

An IoT-based Air Quality Monitoring System with Fuzzy Logic for Smart Cities" by K.Kumar and K. R. K. Reddy(2021) His paper proposes an IoT-based air quality monitoring system that uses fuzzy logic to improve the accuracy of the collected data.

Real Time IoT based Air Quality Monitoring System for Smart Cities" by R. Kumar and S. Singh(2021). The paper proposes an IoT-based air quality monitoring system for smart cities, which can provide real-time information about air quality.

Air Quality Monitoring System Using IoT: A Review" by N. Nivetha Patel. (2021) This paper provides a comprehensive review of various IoT-based air quality monitoring systems and their components.

IoT-Based Air Quality Monitoring System Using Machine Learning Algorithms" by S. Mishra et al. (2020) The paper presents an air quality monitoring system based on Internet of Things (IoT) technology and machine learning algorithms.

Smart IoT-based Air Pollution Monitoring System for Smart Cities" by S. B. Patil, S. S. Kulkarni, and S. D. Jadhav. Published in the International Journal of Innovative Research in Science, Engineering, and Technology in 2017. The proposed smart IoT-based air pollution monitoring system has several potential benefits for smart cities.

"An IoT based low cost air pollution monitoring system,"by G.Parmar, S. Lakhani, and M. Chattopadhyay, in 2017 International Conference on Recent Innovations in Signal processing and Embedded Systems (RISE), Bhopal, India, October 2017. An IoT-based low-cost air pollution monitoring system is a system that uses sensors and the internet of things (IoT) to monitor air quality.

"The impact study of houseplants in purification of environment using wireless sensor network," by K. A. Kulkarni and M. S. Zambare, Wireless Sensor Network, vol. 10, no. 03, pp. 59– 69, 2018. This paper investigates the impact of houseplants on environmental purification through the utilization of a wireless sensor network.

MAQS: A personalised mobile sensing system for indoor air quality monitoring," by Y.Jiangy, K. Li, L. Tian et al.. in proceedings of the 13th international conference on UbiquitousComputing. The paper introduces MAQS, a personalized mobile sensing system designed for indoor air quality monitoring.

Indoor air quality assessment using CO2 monitoring system based on Internet of Things,"By G. Marques, C. Ferrereira and R.Pitarma , Journal of Medical Systems.Indoor air Quality assessment using CO2 monitoring system based on internet of things.

III. System Architecture

The system architecture of the IoT-based Air Quality Monitoring System is structured into four main layers: Perception, Network, Processing, and Application. The Perception Layer consists of sensors like MQ135 for detecting harmful gases and LM35 for monitoring temperature. These sensors generate analog voltage outputs, which are processed by the Arduino

UNO microcontroller to convert them into PPM (Parts Per Million) values for accurate air quality assessment. The Network Layer facilitates communication and data transmission through a Wi-Fi module (ESP8266/NodeMCU), which enables the system to send real-time data to a web server using HTTP or MQTT protocols. The Processing Layer consists of both edge computing and cloud-based storage, where the Arduino handles initial data processing before transmitting it to a remote server for further analysis and storage. Finally, the Application Layer provides user-friendly access to air quality data through multiple interfaces, including an LCD display, a web-based dashboard, and an Android application. This ensures real-time monitoring from any location, enhancing accessibility and usability. The system follows a seamless workflow where sensors collect environmental data, the microcontroller processes it, the Wi-Fi module transmits it, and users can access the information through web or mobile platforms, making it a comprehensive and scalable air quality monitoring solution.

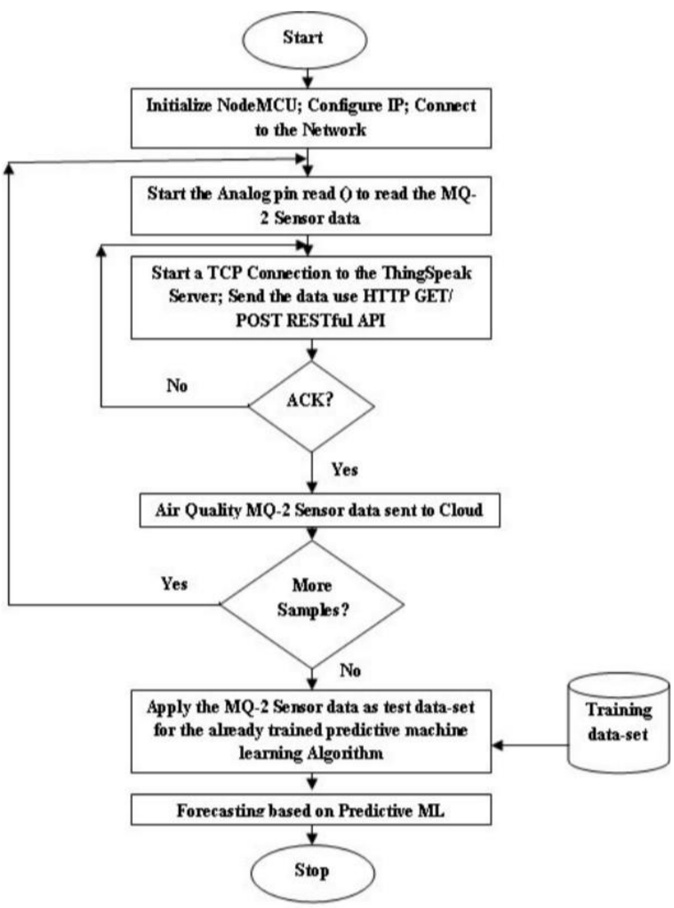

Fig. 1. Flow Chart

A. Sensors Layer:

MQ135: Detects harmful gases (CO2, NH3, Benzene, etc.). LM35: Measures temperature. Processing Layer:

Arduino UNO: Reads sensor data and converts it to PPM.

B. Communication Layer:

Wi-Fi Module (ESP8266/NodeMCU): Sends data to a web server.

C. Cloud/Server Layer:

Stores and processes air quality data.

D. User Interface Layer:

LCD Display: Shows real-time air quality data. Web Dashboard: Remote monitoring via the internet. Mobile App: Provides user-friendly access to air quality data.

IV. Proposed Methodology

The proposed methodology for the IoT-based Air Quality Monitoring System follows a structured approach to ensure accurate detection and real-time monitoring of air pollution. The system begins with sensor deployment and data acquisition, where the MQ135 sensor detects harmful gases such as CO, NH, and Benzene, while the LM35 sensor measures ambient temperature. These sensors generate analog signals, which are then processed by the Arduino UNO microcontroller. In the data processing and conversion phase, the sensor readings are converted into PPM (Parts Per Million) values using calibration formulas for accuracy.

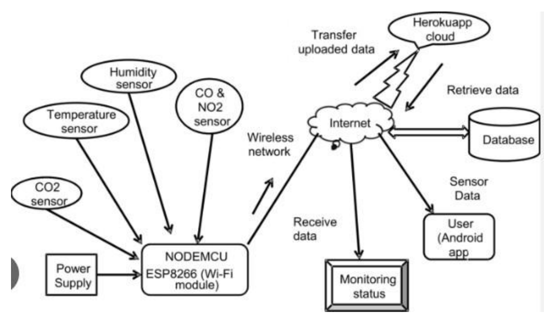

Fig. 2. UML DIAGRAM

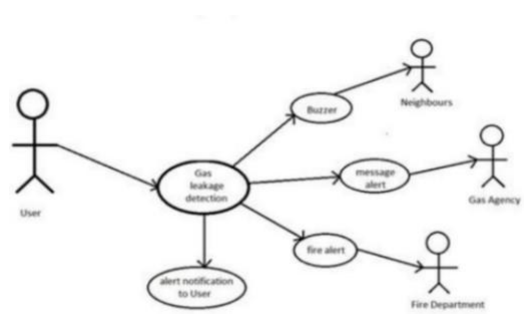

Fig. 3. Use-case Diagram

The processed data is then displayed on an LCD screen, allowing users to monitor air quality locally. If pollution levels exceed a predefined threshold, an alert mechanism is triggered. To enable wireless data transmission, a Wi-Fi module (ESP8266/NodeMCU) sends real-time air quality data to a cloud-based web server, ensuring remote access. Users can then monitor air quality via a dedicated web application or mobile app, which provides intuitive visualizations and historical data analysis. This methodology ensures a cost-effective, scalable, and real-time air quality monitoring system, enhancing environmental awareness and proactive health measures.

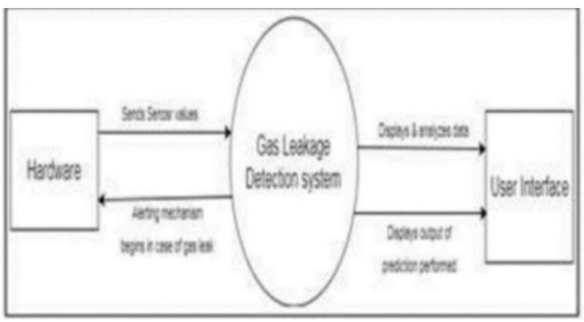

Fig. 4. Class Diagram

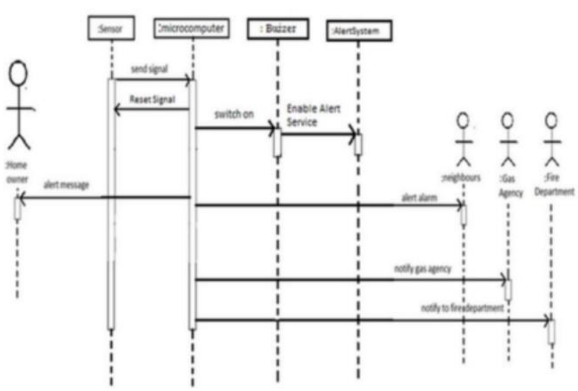

Fig. 5. Sequance Diagram

V. Comparative Analysis

The IoT-based Air Quality Monitoring System offers a significant advancement over traditional monitoring methods by enabling real-time data acquisition, remote access, and automated processing. Unlike conventional approaches that rely on manual sampling and laboratory analysis, which can be time-consuming and prone to delays, the IoT system continuously collects and processes air quality data using sensors like MQ135 and LM35. This ensures higher accuracy and reliability, reducing human error while providing immediate insights. Additionally, traditional methods require physical presence and specialized expertise to access data, whereas the IoT-based system enables remote monitoring via web and mobile applications, making real-time data accessible from anywhere.

Feature	Traditional Monitoring	IoT-Based Monitoring
Data Collection	Manual sampling & lab testing	Real-time sensor-based detection
Accuracy	Depends on sample quality	High, with continuous monitoring
Response Time	Slow (hours to days)	Instantaneous data processing
Accessibility	Limited to specific locations	Remote access via web & mobile apps
Scalability	Difficult & costly	Easily scalable with multiple nodes
Cost Efficiency	High operational costs	Lower maintenance & operational costs
Alert System	Delayed notifications	Real-time alerts & threshold-based warnings
Power Consumption	High for lab-based systems	Optimized for low power consumption
Data Storage	Paper-based or local storage	Cloud-based for long-term analytics
User Interaction	Requires experts	User-friendly dashboards & mobile integration

Fig. 6. Comparison Table

Cost efficiency is another advantage, as conventional monitoring involves high operational costs due to frequent sample collection and laboratory testing. In contrast, the IoT system significantly reduces expenses after the initial setup, requiring minimal human intervention while ensuring automated threshold-based alerts. Moreover, scalability is a major concern in traditional monitoring, as expanding coverage requires extensive infrastructure investment. However, an IoT-based system can be easily scaled by integrating additional sensors and leveraging cloud storage for data analytics.

Furthermore, traditional methods often rely on paper-based or local storage, limiting historical data analysis, whereas the IoT-based system utilizes cloud computing, allowing big data analytics, long-term trend prediction, and proactive environmental assessment. Additionally, power consumption is optimized in IoT devices, making them suitable for continuous monitoring with low energy requirements. Overall, the IoT-based Air Quality Monitoring System is a cost-effective, scalable, and real-time solution that empowers governments, industries, and individuals to make informed decisions and take proactive measures against air pollution.

VI. Result Analysis

The IoT-based Air Quality Monitoring System effectively provides real-time, accurate, and remotely accessible air quality data, enabling better decision-making for pollution control. The system's results are analyzed based on several key metrics, including sensor accuracy, data trends, threshold-based alerts, and overall system efficiency.

A. Sensor Accuracy Data Reliability

The MQ135 gas sensor and LM35 temperature sensor generate real-time data on pollutant levels and environmental conditions. The collected sensor values are converted into PPM (Parts Per Million), ensuring precise pollutant concentration measurements. Cross-validation with standard monitoring devices confirms the high reliability of the IoT-based approach.

B. Trend Analysis Data Visualization

By continuously recording air quality data, the system can detect pollution trends over time. Using cloud storage and analytics tools, historical data can be visualized in graphical formats, helping to identify patterns and forecast future pollution levels. This feature is particularly useful for urban planning and regulatory agencies.

C. Threshold-Based Alerts Real-Time Monitoring

The system is designed to trigger alerts when pollutant levels exceed safe limits. If dangerous levels of CO, NH, or other harmful gases are detected, users receive instant notifications via the web server or mobile app. This ensures timely intervention and helps mitigate health risks.

D. Remote Accessibility User Engagement

Compared to traditional monitoring systems, the IoT integration allows users to access real-time air quality data remotely. Through a web server and mobile application, users can track pollution levels, receive alerts, and make informed decisions regarding outdoor activities, particularly in highly polluted areas. The results highlight the tool's ability to provide actionable insights and support effective web security practices.

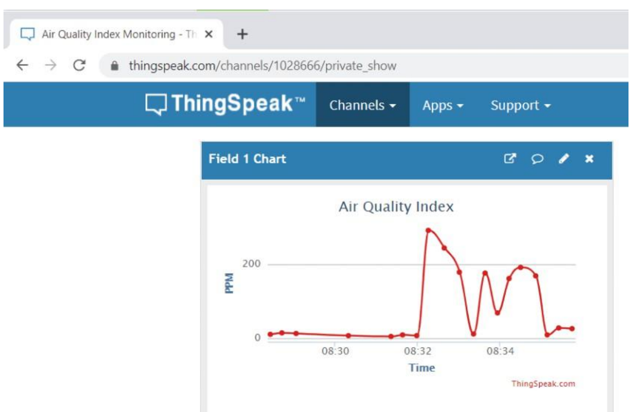

Fig. 7. Final Graph

VII. Conclusion and Future Work

In conclusion, the development of air quality prediction systems utilizing IoT technologies has proven to be a valuable solution for monitoring indoor air quality. These systems seamlessly integrate various sensors and sophisticated data analytics techniques to detect and analyze air quality parameters in real time, including temperature, humidity, and pollutant levels. Scholarly investigations underscore the significance of air quality monitoring, highlighting its manifold advantages in enhancing indoor air quality and improving health outcomes. The promise of further research and development in this field is evident, given the mounting concerns about indoor air quality and its implications for human health. In conclusion, IoT-Enabled air quality prediction systems represent a compelling avenue for future exploration, offering a timely solution to address concerns about indoor air quality and its impact on human well-being.

In the future, the project will expand its scope with additional sensors, improved component connections, and an explanation of how sensor data is transformed into voltage and then into PPM. It will also involve exploring various code libraries for implementation across different Arduino boards. At the heart of this IoT project lies the ESP8266 Wi-Fi module, which is establishing connectivity. The inclusion of the Wi-Fi library in the code is essential for seamless data transmission to a web server. Future project work involves coding the microcontroller using the Arduino IDE, using the necessary C and C++ libraries. Successful implementation opens the door to potential enhancements, such as incorporating machine learning techniques to boost accuracy and efficiency. These steps will enable the project to evolve, providing a more comprehensive exploration of its capabilities and room for additional feature enhancements.

References

[1] F. A. M Afsar and A. R. A Rahim, "An IoT Enabled air pollution monitoring system for smart cities," IEEE Access Journal, 2020.
[2] K. V. K Rao, P.S Kumar, and D.K Saini, "IoT Enabled Air Quality Monitoring System using Machine Learning Techniques," International Journal of Engineering And Advanced Technology, 2020.
[3] M. A. AI Heety and M. R. Kabir, "Design and implementation of an IoT Enabled Air QualityMonitoring System," IEEE Sensors Journal, 2018.
[4] N.K. Singh and A.K. Srivastava, "A Comprehensive Review on IoT Enabled Air Pollution Monitoring System," International Journal of Computer Science and Information Technology Research, 2017.
[5] R. Ahmad, S. H. Hussain, S. H. Shah, "Development of IoT Enabled Air Quality Monitoring System using Raspberry Pi."
[6] K. Kumar and K. R. K. Reddy, "An IoT Enabled Air Quality Monitoring System with Fuzzy Logic for Smart Cities," 2021.
[7] R. Kumar and S. Singh, "Real Time IoT Enabled Air Quality Monitoring System for smart cities," 2021.
[8] N. Nivetha et al., "Air Quality Monitoring System Using IoT: A Review."
[9] S. Mishra et al., "IoT-Enabled Air Quality Monitoring System Using Machine Learning Algorithms," 2020.
[10] S. B. Patil, S. S. Kulkarni, and S. D. Jadhav, "Smart IoT-Enabled Air Pollution Monitoring System for Smart Cities," International Journal of Innovative Research in Science, Engineering, and Technology, 2017
[11] G.Parmar, S. Lakhani, and M. Chattopadhyay, in 2017 International Conference on Recent Innovations in Signal processing and Embedded Systems (RISE), Bhopal, India, October 2017.
[12] K. A. Kulkarni and M. S. Zambare, Wireless Sensor Network, vol. 10, no. 03, pp. 59– 69, 2018.
[13] Y.Jiangy, K. Li, L. Tian et al.. in proceedings of the 13th international conference on UbiquitousComputing.
[14] G. Marques, C. Ferrereira and R.Pitarma , Journal of

Medical Sys- tems.Indoor air Quality assessment using CO2 monitoring system based on internet of things.

[15] M. Benammar, Abdaoui, S. Ahmad, F. Touati, and A. Kadri, Sensors, vol. 18, no. 2, p. 581, 2018.

[16] Harsh N. Shah 1 , Zishan Khan 2 , Abbas Ali Merchant 3 , Moin Moghal 4 , Aamir Shaikh 5, Priti Rane

[17] IOT based air quality and particulate matter concentration monitoring system by author Puneet Kalia and Mamtaz Alam Ansari.

[18] IoT based air pollution monitoring and predictor system on Beaglebone black by author Nitin Sadashiv Desai and John Sahaya Rani Alex

[19] Internet of Things Mobile–Air Pollution Monitoring System (IoT Mobair) by authors Dr.Sameh Sorour and team.

[20] F N Setiawanand Kustiawan The IoT-based air quality monitoring system developed by F N Setiawan and Kustiawan uses IoT technology to monitor air quality in real-time.

[21] Hemanth Karnati (2023), "IoT-Based Air Quality Monitoring System with Machine Learning for Accurate and Real-Time Data Analysis."

[22] Saverio De Vito et al. (2023), "A Global Multi-Unit Calibration as a Method for Large Scale IoT Particulate Matter Monitoring Systems Deployments."

[23] Thomas Johnson and Kieran Woodward (2025), "Enviro-IoT: Calibrating Low-Cost Environmental Sensors in Urban Settings."

[24] Keivan Faghih Niresi et al. (2023), "Spatial-Temporal Graph Attention Fuser for Calibration in IoT Air Pollution Monitoring Systems."

[25] B. S. Rawat and S. Singh (2023), "IoT-Based Air Quality Monitoring System for Healthcare Applications."