



BreathX: A Personal Air Quality Checker using IOT

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ABSTRACT

Air pollution has become one of the major environmental and public health concerns across the world, especially in rapidly growing urban and industrial areas. Increasing industrialization, vehicular emissions, fossil fuel combustion, and population growth have significantly contributed to the rise of harmful pollutants in the atmosphere. Continuous exposure to polluted air can lead to severe respiratory disorders, cardiovascular diseases, allergies, and other long-term health complications. Therefore, monitoring air quality has become essential for maintaining human health and environmental sustainability.

Traditional air quality monitoring systems are generally expensive, stationary, and limited to specific locations. Although these systems provide accurate environmental analysis, they are not easily accessible for personalized and real-time monitoring applications. As a result, there is a growing demand for portable, low-cost, and intelligent environmental monitoring systems capable of providing localized air quality information to users.

To address these challenges, this research proposes “BreathX: Personal Air Quality Checker,” an IoT-based smart environmental monitoring system designed for real-time air quality analysis and environmental awareness. The proposed system utilizes NodeMCU ESP8266 as the central microcontroller because of its compact architecture, low power consumption, and built-in Wi-Fi communication capability. The system integrates MQ135 gas sensor for harmful gas detection and DHT11 sensor for monitoring temperature and humidity conditions.

The collected environmental data is processed by the NodeMCU and transmitted wirelessly to the ThingSpeak cloud platform for remote monitoring, data storage, and graphical visualization. The system also includes an OLED display module for local real-time monitoring of

environmental conditions. In addition, an SG90 servo motor is incorporated as an alert mechanism that activates whenever unsafe air quality levels are detected, thereby improving environmental awareness and user safety.

One of the major advantages of the proposed BreathX system is its portability, affordability, and ease of implementation. The system can be effectively used in homes, schools, hospitals, workplaces, industries, and smart environmental monitoring applications. The experimental observations demonstrated that the proposed model efficiently detects environmental changes and provides continuous real-time monitoring with wireless cloud connectivity.

Compared to conventional environmental monitoring systems, BreathX offers advantages such as low implementation cost, portability, energy-efficient operation, cloud-based monitoring, and intelligent alert generation. Furthermore, the proposed system contributes toward improving personalized environmental awareness and preventive healthcare monitoring.

Future enhancements of the system may include integration of PM2.5 and PM10 particulate sensors, mobile application support, GPS-enabled environmental mapping, and artificial intelligence techniques for predictive air quality analysis. These improvements can further increase the efficiency, scalability, and intelligence of the proposed environmental monitoring system.

In conclusion, BreathX presents an efficient, practical, and scalable IoT-based air quality monitoring solution capable of providing real-time environmental analysis and improving public environmental awareness. The proposed model represents an important step toward the development of smart environmental monitoring technologies and healthier living environments.

Keywords— Internet of Things (IoT), Air Quality Monitoring, NodeMCU ESP8266, MQ135 Sensor, DHT11 Sensor, HC-SR04, ThingSpeak, Environmental Monitoring, Real-Time Data

Analysis, Smart Health Systems, Cloud Computing, Personalized Air Quality Checker.

I. INTRODUCTION

Air pollution has become one of the most critical environmental challenges affecting human health and ecological balance worldwide. Rapid industrialization, urban development, vehicular emissions, fossil fuel combustion, and population growth have significantly increased the concentration of harmful pollutants in the atmosphere. Polluted air contains toxic gases and suspended particles that negatively affect respiratory health, cardiovascular systems, and overall human well-being. According to environmental studies and health organizations, prolonged exposure to poor air quality can result in asthma, lung infections, allergies, chronic respiratory disorders, and reduced life expectancy. Urban regions especially experience severe air quality degradation due to increasing traffic congestion and industrial activities.

Traditional air quality monitoring systems are generally implemented through government-operated monitoring stations equipped with sophisticated analytical instruments. These systems measure environmental pollutants such as carbon monoxide (CO), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ozone (O₃), and particulate matter (PM_{2.5} and PM₁₀). Although these monitoring stations provide highly accurate environmental data, they are expensive, stationary, and limited to selected geographical locations. As a result, individuals often lack access to localized and real-time air quality information regarding their immediate surroundings. This creates a need for affordable, portable, and user-friendly environmental monitoring systems capable of providing personalized environmental awareness.

Recent advancements in the Internet of Things (IoT), embedded systems, and wireless communication technologies have enabled the development of smart environmental monitoring solutions. IoT-based monitoring systems integrate sensors, microcontrollers, cloud platforms, and wireless communication modules to collect, process, and transmit environmental data in real time. These systems provide advantages such as low implementation cost, remote accessibility, portability, continuous monitoring, and cloud-based data visualization.

In this context, the proposed system “BreathX: Personal Air Quality Checker” is developed as a smart IoT-based portable environmental monitoring solution capable of analyzing surrounding air conditions in real time. The system utilizes NodeMCU ESP8266 as the central processing and communication unit due to its built-in Wi-Fi capability and compact architecture. The MQ135 gas sensor is used to detect harmful gases and monitor air pollution levels, while the DHT11 sensor measures ambient temperature and humidity conditions. Additionally, the HC-SR04 ultrasonic sensor enables proximity-based smart activation, improving system efficiency and reducing unnecessary power consumption.

The environmental data collected by the sensors is processed by the NodeMCU and transmitted wirelessly to the ThingSpeak cloud platform for remote monitoring, graphical visualization, and data storage. The system also incorporates an OLED display module for local real-time monitoring of environmental parameters. Furthermore, an SG90 servo motor is integrated as an alert mechanism that activates whenever

harmful gas concentration exceeds predefined safety levels, thereby improving user awareness and environmental safety.

The proposed BreathX system focuses on providing a low-cost, portable, and scalable environmental monitoring solution suitable for homes, workplaces, educational institutions, healthcare environments, and industrial safety applications. Compared to conventional monitoring systems, the proposed model offers advantages such as portability, real-time monitoring, wireless cloud communication, intelligent activation, and user-friendly operation.

Future enhancements of the proposed system may include integration of PM_{2.5} and PM₁₀ particulate sensors, mobile application support, AI-based pollution prediction, GPS-enabled environmental mapping, and machine learning techniques for intelligent environmental analysis. Therefore, BreathX represents an efficient and practical IoT-driven solution for personalized air quality monitoring and smart environmental awareness.

II. LITERATURE REVIEW

Air quality monitoring has become an important research area due to the increasing impact of environmental pollution on public health and ecological sustainability. Researchers have proposed various environmental monitoring systems using wireless sensor networks, embedded systems, IoT technology, and cloud computing platforms for real-time environmental analysis. Most existing systems focus on pollutant detection, cloud-based monitoring, and wireless data communication. However, limitations related to cost, portability, scalability, and personalized monitoring still exist in many proposed models.

Osmani et al. proposed a real-time air quality monitoring framework for analyzing pollutants such as carbon dioxide and nitrogen dioxide in urban environments. The system utilized advanced environmental sensors and compared collected data with environmental standards for pollution analysis. Although the system provided accurate monitoring results, the implementation required expensive sensing infrastructure and was mainly limited to fixed monitoring stations.

Mahmood et al. developed a low-cost indoor air quality monitoring system using Arduino-based architecture integrated with MQ-series gas sensors and DHT11 environmental sensors. The collected data was transmitted to the ThingSpeak cloud platform for remote visualization and analysis. The study demonstrated the effectiveness of IoT-based monitoring systems; however, the proposed model focused mainly on indoor applications and lacked intelligent alert mechanisms and smart automation features.

Tamrakar et al. introduced an IoT-based air quality monitoring and alert system using ESP32 controllers and multiple gas sensors for urban pollution analysis. The system provided cloud connectivity and real-time environmental alerts. Although the architecture improved real-time monitoring capability, the integration of multiple sensors increased system complexity, calibration requirements, and power consumption.

Karar et al. proposed “GASDUINO,” a wireless environmental monitoring system using Arduino UNO, MQ135 gas sensors, and ESP8266 Wi-Fi communication modules. The system provided real-time environmental analysis through IoT-based wireless communication. However, the system lacked advanced

cloud analytics, intelligent activation mechanisms, and multi-parameter environmental monitoring capabilities.

Recent research trends in environmental monitoring emphasize the use of IoT platforms, wireless communication technologies, cloud computing, and smart sensing techniques for real-time environmental analysis. Modern systems focus on portability, energy efficiency, remote monitoring, and user accessibility. Cloud platforms such as ThingSpeak, Blynk, and AWS IoT are increasingly being used for environmental data storage, visualization, and analytics.

Despite these advancements, several limitations still exist in existing air quality monitoring systems. Many proposed systems are expensive, stationary, energy-intensive, or designed mainly for industrial applications rather than personal monitoring. Some systems lack smart activation mechanisms, cloud-based analytics, real-time alerts, or portable architectures suitable for daily environmental awareness.

To address these limitations, the proposed system “BreathX: Personal Air Quality Checker” introduces a low-cost, portable, and IoT-enabled environmental monitoring framework capable of real-time air quality analysis. The proposed model integrates MQ135 gas sensing, DHT11 environmental monitoring, HC-SR04 smart activation, cloud-based ThingSpeak visualization, and SG90 servo alert mechanisms using NodeMCU ESP8266. The system emphasizes portability, affordability, energy efficiency, and personalized environmental monitoring suitable for smart environmental applications.

III. MATERIALS AND METHODOLOGY

The proposed system “BreathX: Personal Air Quality Checker” is developed using IoT technology for real-time environmental monitoring and analysis. The system integrates multiple sensors, wireless communication, cloud computing, and alert mechanisms to provide a portable and smart air quality monitoring solution. The methodology mainly focuses on environmental data collection, processing, cloud-based visualization, and user alert generation.

The system is designed using NodeMCU ESP8266 as the central processing and communication unit due to its built-in Wi-Fi capability and compact architecture. The MQ135 gas sensor is used to detect harmful gases and monitor air pollution levels in the surrounding environment. The sensor can identify gases such as carbon dioxide, ammonia, smoke, benzene, and other toxic pollutants. To monitor environmental conditions more effectively, the DHT11 sensor is integrated into the system for measuring ambient temperature and humidity.

An HC-SR04 ultrasonic sensor is incorporated to implement proximity-based smart activation. The ultrasonic sensor continuously detects user presence within a predefined range and activates the environmental monitoring process only when necessary. This approach helps reduce unnecessary power consumption and improves the efficiency of the overall system.

The collected environmental data is continuously processed by the NodeMCU microcontroller. The processed sensor readings are displayed locally on the OLED display module for real-time monitoring. Simultaneously, the environmental

data is transmitted wirelessly to the ThingSpeak cloud platform using Wi-Fi communication. The cloud platform stores the data and generates graphical visualization for remote monitoring and environmental analysis.

To improve environmental awareness and user safety, an SG90 servo motor is integrated as an alert mechanism. Whenever the detected gas concentration exceeds predefined safety limits, the servo motor is activated to generate a physical alert indication. The complete monitoring process operates continuously in a cyclic manner to provide uninterrupted real-time environmental analysis.

The hardware components used in the proposed system include NodeMCU ESP8266, MQ135 gas sensor, DHT11 temperature and humidity sensor, HC-SR04 ultrasonic sensor, SG90 servo motor, OLED display module, breadboard, jumper wires, and power supply. The software implementation is carried out using Arduino IDE and Embedded C/C++ programming language along with ThingSpeak cloud integration and required IoT libraries.

The proposed methodology provides a low-cost, portable, energy-efficient, and IoT-enabled environmental monitoring solution suitable for homes, healthcare environments, educational institutions, workplaces, and smart city applications.

IV. PROPOSED SYSTEM

The proposed BreathX system is designed using an IoT-based smart environmental monitoring architecture that integrates multiple sensors, wireless communication modules, cloud connectivity, and intelligent alert mechanisms. The system continuously monitors harmful gas concentration, temperature, and humidity levels in real time while providing both local and remote environmental monitoring capabilities. The architecture is designed to be portable, low-cost, energy-efficient, and suitable for personalized environmental monitoring applications.

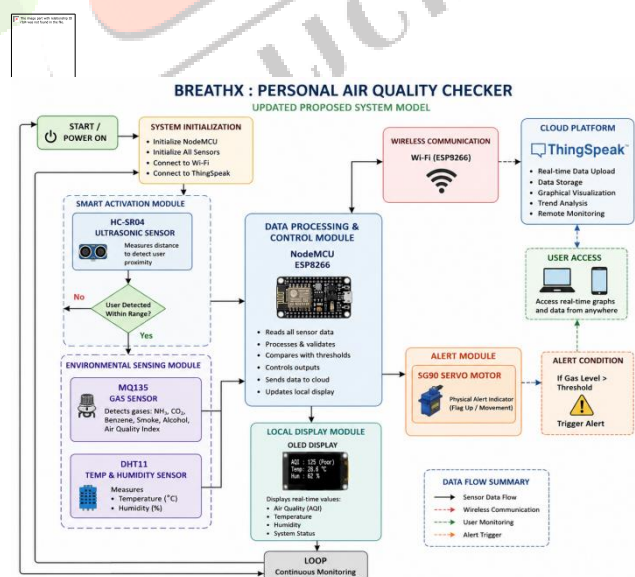
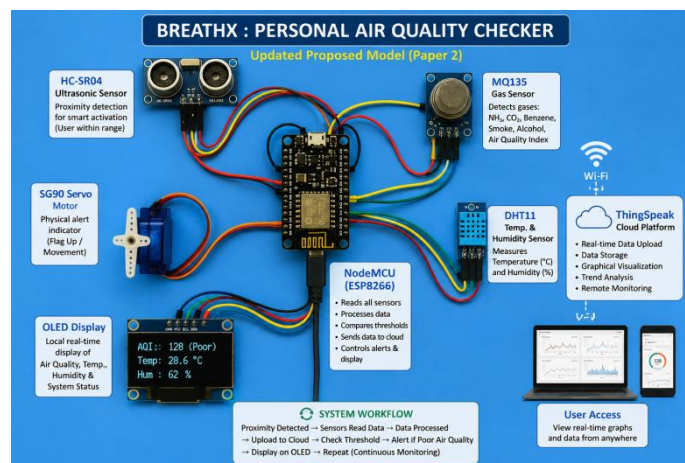


Figure 1 Proposed Model

The system utilizes NodeMCU ESP8266 as the central processing and communication unit responsible for collecting sensor data, processing environmental readings, and transmitting the information to the cloud platform through Wi-Fi communication. The integration of MQ135 gas sensor, DHT11 environmental sensor, HC-SR04 ultrasonic sensor,

OLED display module, and SG90 servo motor enables efficient environmental monitoring and real-time user awareness.



The hardware implementation of the proposed system demonstrates the practical integration of sensors, cloud communication modules, and alert mechanisms used for real-time environmental analysis. The MQ135 sensor continuously detects harmful gases and air pollution levels, while the DHT11 sensor measures ambient temperature and humidity conditions. The HC-SR04 ultrasonic sensor enables proximity-based smart activation to improve energy efficiency and reduce unnecessary system operation.

The collected environmental data is processed by the NodeMCU and displayed locally on the OLED display module for immediate monitoring. Simultaneously, the environmental readings are transmitted to the ThingSpeak cloud platform for remote monitoring, graphical visualization, and environmental data analysis. Whenever unsafe gas concentration levels are detected, the SG90 servo motor generates a physical alert indication to improve user safety and environmental awareness. The complete system operates continuously to provide uninterrupted real-time air quality monitoring suitable for homes, healthcare environments, workplaces, educational institutions, and smart environmental applications.

V. OBSERVATION AND CONCLUSION

The proposed “BreathX: Personal Air Quality Checker” system was successfully implemented and tested under different environmental conditions to analyze its monitoring performance and operational efficiency. The system effectively monitored harmful gas concentration, temperature, humidity, and user proximity while continuously transmitting environmental data to the ThingSpeak cloud platform for remote monitoring and graphical visualization.

The MQ135 gas sensor successfully detected variations in air quality and responded efficiently to polluted environmental conditions such as smoke and harmful gas exposure. The DHT11 sensor continuously measured ambient temperature and humidity and provided stable environmental readings. The HC-SR04 ultrasonic sensor accurately detected user presence and activated the monitoring process only when required, thereby reducing unnecessary power consumption and improving system efficiency.

The NodeMCU ESP8266 processed all sensor readings efficiently and transmitted the collected environmental data wirelessly through Wi-Fi communication. The OLED display module provided real-time local monitoring of gas concentration, temperature, humidity, and system status. Whenever unsafe environmental conditions were detected, the SG90 servo motor generated a physical alert indication to improve environmental awareness and user safety.

The experimental observations demonstrated that the proposed system provides reliable real-time environmental monitoring, cloud-based visualization, intelligent alert generation, low-cost implementation, portability, and energy-efficient operation. The system can be effectively utilized in homes, educational institutions, healthcare environments, workplaces, and industrial safety applications for continuous environmental monitoring and awareness.

In conclusion, the proposed BreathX system presents an efficient and practical IoT-based environmental monitoring solution capable of providing personalized air quality analysis and real-time environmental awareness. The integration of cloud communication, smart activation, and alert mechanisms improves the overall usability and effectiveness of the system. Future enhancements such as PM2.5 and PM10 sensing, AI-based pollution prediction, mobile application support, GPS integration, and machine learning techniques can further improve the intelligence and scalability of the proposed model.

VI. REFERENCES

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