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Breath Safe Real Time Monitoring System

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Abstract
Air pollution is not just an environmental concern; it's a serious threat to public health, especially as cities expand and industries grow. When you consider all the chemicals we use daily, it's easy to see why monitoring air quality is so important. That's where the Breath Safe Real-Time Air Monitoring System comes in. It's an affordable and smart solution to track what's in the air we breathe. Here's how it works: this system employs several sensors to detect pollutants that matter, such as $PM_{2.5}$, PM_{10}, CO_2, CO, and NO_2. It also monitors temperature and humidity. All this data is processed and sent wirelessly through Wi-Fi or GSM to a cloud platform. This way, you receive real-time updates, and all your readings are stored securely. There's also an app. It's easy to use and displays your Air Quality Index (AQI) numbers directly on your phone. If pollution levels rise above a safe threshold, you receive an alert. You'll also find health tips and advice, so you know what to do. The goal is to raise awareness, help communities respond quickly when air quality declines, and make everyday life a little safer by providing easy access to air quality information.
Keywords: *Internet of Things (IoT), Air Quality Monitoring, Real-Time Monitoring, Air Quality Index (AQI), Environmental Monitoring, Gas Sensors, Wireless Sensor Networks, Cloud Computing, Smart City, Pollution Detection.*

1. Introduction
Air pollution is one of the most critical environmental challenges affecting human health, climate stability, and sustainable development. Rapid urbanization, industrial growth, and increased vehicular emissions have significantly contributed to the rise in harmful pollutants such as particulate matter ($PM_{2.5}$, PM_{10}) and toxic gases like CO, CO_2, and NO_2. Prolonged exposure to these pollutants can lead to severe respiratory and cardiovascular diseases, making continuous air quality monitoring essential. Traditional air quality monitoring systems, primarily deployed by government agencies, provide accurate measurements but suffer from high installation costs, limited spatial coverage, and lack of real-time accessibility for common users. These systems are often centralized and fail to deliver localized air quality information, which is crucial for timely decision-making. With the advancement of Internet of Things (IoT) technology, low-cost and distributed monitoring solutions have become feasible. IoT enables the integration of multiple sensors, real-time data acquisition, and wireless communication for continuous environmental monitoring. In this context, this paper proposes the *Breath Safe Real-Time Air Monitoring System*, an IoT-based solution designed to measure air pollutants and environmental parameters in real time. The system utilizes multi-sensor integration, cloud-based data processing, and mobile application interfaces to provide real-time Air Quality Index (AQI), alerts, and health recommendations. The proposed approach aims to enhance environmental awareness, improve accessibility to air quality data, and support smart city initiatives. [1-5]

1.1. Problem Statement
Air pollution has become a critical environmental and public health issue due to rapid industrialization, urbanization, and increased vehicular emissions. Existing air quality monitoring systems, such as government-installed stations, provide highly accurate data but are limited by high cost, fixed deployment, and low spatial coverage. As a result,

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real-time and location-specific air quality information is not easily accessible to the general public. Furthermore, conventional monitoring solutions lack continuous real-time data transmission, user-friendly visualization, and instant alert mechanisms. This creates a gap between environmental data availability and user awareness, preventing timely preventive actions against hazardous air conditions. In addition, the absence of portable and scalable monitoring devices restricts the ability to analyze pollution variations across different locations. Therefore, there is a need for an efficient, low-cost, and IoT-based system that can provide real-time air quality monitoring, data analysis, and alert notifications to enhance environmental awareness and public health safety [6-10]

1.2. Objectives

The primary objective of this work is to design and implement an IoT-enabled real-time air quality monitoring system capable of accurate sensing, processing, and transmission of environmental data. The system integrates multiple gas sensors and environmental sensors to measure key pollutants such as $PM_{2.5}$, PM_{10}, CO_2, CO, and NO_2, along with temperature and humidity, ensuring high sensitivity and fast response time. It aims to perform efficient data acquisition through Analog-to-Digital Conversion (ADC) and apply sensor calibration techniques for improved measurement accuracy. The system utilizes wireless communication protocols such as MQTT/HTTP over Wi-Fi or GSM for reliable data transmission to a cloud-based platform. Furthermore, it focuses on real-time computation of the Air Quality Index (AQI) and visualization through a mobile application interface. A threshold-based alert mechanism is implemented to generate instant notifications when pollutant levels exceed permissible limits. The overall objective is to develop a scalable, low-power, and robust monitoring solution suitable for smart city and environmental surveillance applications.

2. Method

The proposed system is designed using a modular IoT architecture consisting of hardware, communication, and application components. The hardware module includes sensors such as MQ-series gas sensors and DHT sensors connected to a microcontroller (Arduino/ESP8266). These sensors collect environmental data continuously. The microcontroller processes the data and converts it into meaningful values using Analog-to-Digital Conversion (ADC). The processed data is transmitted to the cloud using Wi-Fi or GSM modules. The cloud platform (Blynk/ThingSpeak) stores and visualizes the data. A mobile application is used to display AQI values and provide alerts when pollution exceeds safe limits. Table 1. [11-15]

Table 1 System Parameters for Breath Safe Real Time Monitoring

SYSTEM MODULE	TOOLS	PRIMARY FUNCTION
Sensor module	MQ sensor, DHT11	Collect air data
Controller	Arduino / ESP8266	Process data
Communication	Wi-Fi / GSM	Transmit data
Cloud Platform	Blynk / ThingSpeak	Store & Visualize
Analysis	WEKA	Data analysis
Mobile App	Blynk App	User interface

2.1. Figures

The system consists of multiple sensors used to detect air pollutants such as $PM_{2.5}$, PM_{10}, CO_2, CO, and NO_2, along with temperature and humidity sensors. These sensors continuously collect environmental data and send it to the microcontroller. The microcontroller processes the collected data and transmits it to the cloud server using communication modules such as Wi-Fi or GSM. The cloud platform stores and analyzes the data in real time. Finally, the processed data is displayed on a mobile application, where users can view Air Quality Index (AQI) values, receive alerts, and access health recommendations. The overall system ensures efficient real-time monitoring and user-friendly visualization of air quality data.

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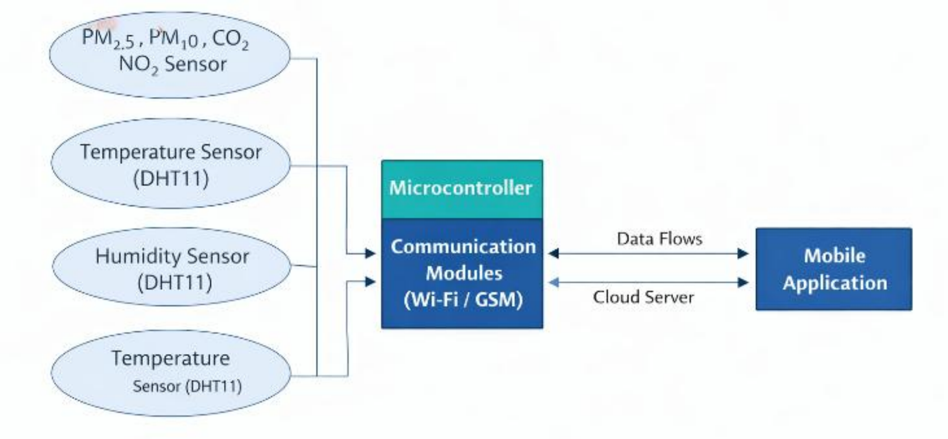

Figure 1 System Architecture of Breath Safe Real Time Monitoring

3. Results and Discussion

3.1.Results

The *Breath Safe Real-Time Air Monitoring System* was tested in different environments such as indoor and outdoor locations to evaluate its performance. The system successfully measured air pollutants including $PM_{2.5}$, PM_{10}, CO_2, CO, and NO_2, along with temperature and humidity. The collected data was transmitted to the cloud platform in real time using Wi-Fi/GSM communication. The system displayed Air Quality Index (AQI) values through a mobile application, enabling users to monitor air quality conditions easily. The alert mechanism was triggered when pollutant levels exceeded predefined safe limits, and notifications were sent to users via the mobile application or SMS. The system showed stable performance with minimal delay in data transmission.

3.2.Discussion

The results demonstrate that the proposed system is effective in providing real-time air quality monitoring with good accuracy and reliability. Compared to traditional monitoring systems, the proposed solution is cost-effective, portable, and easy to deploy in multiple locations. The integration of IoT technology allows continuous monitoring and remote accessibility, which improves user awareness and supports timely decision-making. The mobile application enhances usability by providing clear visualization of AQI values and health recommendations. However, certain limitations were observed. Sensor accuracy may vary due to environmental conditions and requires proper calibration. Additionally, the system depends on network connectivity for real-time data transmission, which may affect performance in low-signal areas. Despite these limitations, the system proves to be an efficient and practical solution for air quality monitoring and can be further improved with advanced sensors and data analysis techniques. Figure 2.

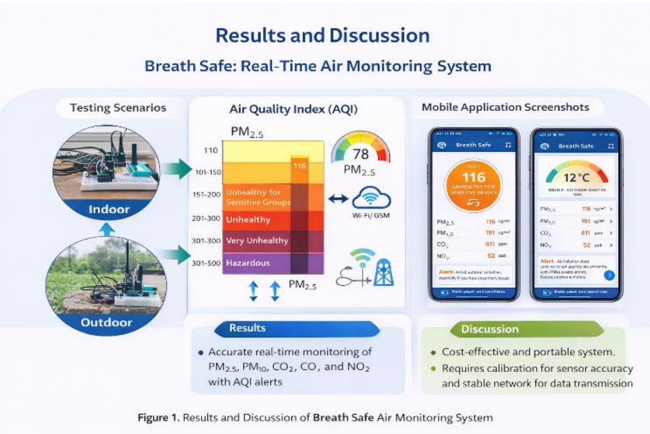

Figure 2 Process of Proposed Methodology

Conclusion

The *Breath Safe Real-Time Air Monitoring System* successfully demonstrates the application of IoT technology in monitoring air quality. The system effectively measures environmental parameters such as $PM_{2.5}$, PM_{10}, CO_2, CO, NO_2, temperature, and humidity, and provides real-time data through a mobile application. The proposed solution overcomes the limitations of traditional monitoring systems by offering a portable, cost-effective, and scalable design. The integration of cloud connectivity and alert mechanisms enables users to receive timely notifications and take preventive actions. The results indicate that the system performs reliably in real-time data acquisition and transmission. Overall, the system enhances environmental awareness and contributes to improving public health. Future enhancements can include advanced sensors, machine learning-based prediction, and GPS integration for location-based monitoring.

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