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# Air Quality Monitoring And Alert

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***Abstract***— **Some widespread environmental problems recognized all over the world include air pollution, which is responsible for a substantial amount of damage to humans and the environment. The current air monitoring system is large, too bulky, and cost-prohibitive for day-to-day use in real-time monitoring of the environment. This project will develop a cost-effective air quality monitoring and alert system. The system will be designed around an ESP32 microprocessor, which will act as the central processing and communication unit. The various sensors within the system will include PMS5003 for measuring particulate matter, BME280 for measuring temperature, humidity and air pressure as well as MQ135 for measuring harmful gases such as carbon dioxide ($CO_2$), ammonia ($NH_3$) and volatile organic chemicals (VOCs). The ESP32 will receive and process the data collected from each of the many different sensors, then will transmit that data to a cloud-based application through Thing speak 10. In addition to this functionality, the system will provide an alerting mechanism that will provide audio alerts via buzzer or sound if any of the pollutants exceed an acceptable threshold value. The overall result is a complete air quality monitoring system that is low-cost, efficient and easily expandable for many different locations and purposes such as smart cities or environmental monitoring. The use of IoT technology to create an effective air quality monitoring and alerting system is demonstrated in this project.**

**Keywords: PMS5003, MQ135 Gas Sensor, BME280 Sensor, Real-Time Monitoring, Cloud Computing, ThingSpeak.**

## I.INTRODUCTION

Air pollution has become a major issue of Modern day urban life as it can directly impact the health of humans and their environment. Air quality monitoring is an important approach for identifying and informing the public about dangerous levels of air pollutants. Also, with the advent of IoT technology, creating an affordable air quality monitoring system is now possible. This project presents the design and implementation of an IoT-based Air Quality Monitoring and Alert System using an ESP32 microcontroller, which serves as the main processing unit. As part of this project, multiple environmental sensors will be utilized, including a PM5003 to measure particulate matter (PM2.5 and PM10), a BME280 to measure temperature, humidity and barometric pressure, and an MQ135 gas sensor to detect dangerous gases (e.g. CO2, NH3 and VOCs). The ESP32 will gather data from all of the sensors and send it to a cloud platform, either using an existing one such as Thing Speak or a developed one. The cloud platform will then store, display and analyze in real-time the collected data regarding air quality. Additionally, if a pollutant's level is above an acceptable level (i.e., defined by the user), the system will send out alerts.Conventional atmospheric quality checking systems usually come occupied or expensive and are fixed permanently. They are not able to be found everywhere equally because of their relatively high costs to install and operate, so they cannot be put down in minor populated zones like small towns and pastoral areas. Furthermore, traditional checking methods cannot be used for implementing movable or up-to-date checking methods. Therefore, the IOT offers a new way of providing atmosphere checking and developing solutions to these difficulties, as it provides a low-cost method of implementing environmental monitoring systems.The IOT is the interconnectedness of real-world physical objects through the internet; therefore, these items can gather, process, and share information without user input. Over the last few years, IOT technologies have delivered tremendous value to many different applications associated with smart cities such as patient care, intelligent farming, motor vehicle movement management, industrial process automation, and environmental monitoring. IOT systems use devices and components (e.g., sensors, microcontrollers, clouds, and wireless communication) that have connecting mechanisms to the internet to create long-term continuous data monitoring of environmental conditions and provide users with up-to-the-minute reports on the present condition of the environment.

## II. LITERATURE SURVEY

Air Pollution Monitoring is one of the research domains which gained importance with the growing public health and environmental sustainable issues. Even though the existing



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monitoring techniques are highly accurate, they are cost-intensive, immobile, and location-constrained. As such, many researchers suggested different IoT-based techniques to overcome these challenges.IoT and WSNIn different research papers, the efficiency of IoT technology in environmental monitoring is discussed. WSN technology, combined with the support of microcontrollers and cloud technology, provides the advantage of remote access to the data collected. It reduces the dependency on static and cost-intensive technology[1],[2]Use of Microcontrollers (Arduino, ESP8266, ESP(32)In different research papers, the usage of different microcontrollers for IoT-based technology is discussed. Arduino Uno and ESP8266 are the most widely used microcontrollers for IoT-based technology. But in recent research papers, ESP32 is used because it is dual-core-based, provides high memory support, and is equipped with Wi-Fi and Bluetooth support, making it the best option and efficient for IoT-based technology applications[7],[8].Air Quality Sensors (PM, Gas, and Environmental)In different research papers, the usage of PM2.5 and PM10 sensors (PM5003) is discussed. It is used to measure the particulate matter in the environment.indicator of respiratory towards health risks[3],[4].Sensors such as the MQ135 sensor can be used for the detection of hazardous gases like $CO_2$, $NH_3$, and VOCs, which is not possible using particulate sensors. Moreover, the BME280 sensor is said to be an effective way to measure temperature, humidity, and pressure, which affect the pollution level and the accuracy of the sensors. Cloud Platforms and Data Utilization: Thing Speak, AWS IoT, Google Firebase, etc., are some cloud platforms used for data visualization and analytics. According to the literature, cloud-based IoT can be used to predict the pollution level, calculate the AQI, and send alerts. It is also possible to design open-source dashboards to disseminate the data to the public. Identified Gap: Even though many IoT-based air quality monitoring systems have been developed, the majority of them consider only one parameter, either particulate matter or gas. Moreover, the majority of the systems lack the feature of sending real-time alerts. Furthermore, the cost is one of the factors hindering the deployment of these systems.

## III.PROPOSED SYSTEM

A real-time and continuous evaluation of the environment has been made possible through an IoT-device-based air quality detection and alert system that provides an affordable, portable, adaptable way to monitor many air-quality variables right where people come into contact with them while solving the issues associated with conventional air quality monitoring stations. Data acquisition, processing, and alert generation are integrated into one complete, effective solution.

## IV.METHODOLOGY

### *Sensing and Data Acquisition*

Different sensors are used to detect different environmental factors. The PM5003 sensor detects the level of particulate matter such as PM2.5 and PM10. The BME280 sensor detects temperature, humidity, and pressure. The MQ135 sensor detects harmful gases such as CO2, NH3, and VOCs. All these sensors send analog/digital data in real-time, reflecting the quality of air in the surrounding environment.

### *Data Processing using ESP32*

The ESP32 microcontroller is used as a processing and control unit. It collects data from all the connected sensors and then processes the raw data to convert it into useful air quality information.Threshold values are set based on air quality types such as Good, Moderate, Poor, Hazardous, etc.

### *Data Transmission to Cloud*

The data from the sensor, which has been processed by the ESP32, is sent to a cloud server like ThingSpeak or a custom-built cloud server through Wi-Fi. The data is then stored in the cloud server. Visualization of data through graphs, charts, etc., can also be done.

### *Alert Mechanism*

This mechanism is part of the system, and it can be utilized to create an alert when measured levels of pollutants go beyond safety thresholds. The ESP32 module continuously compares measured levels of pollutants with threshold levels to determine the quality of air.When levels of pollutants go beyond safety thresholds, an alert mechanism can be initiated to notify people in real-time. Alerts can be sent using SMS and emails through cloud services or APIs, enabling people to be aware of environmental conditions even if they are not physically close to the device.This alert mechanism helps people become aware of hazardous environmental conditions and can be utilized effectively for preventive measures. It can improve the effectiveness of this system because it allows for local and remote monitoring.

### *Utilization and Research Contribution*

The data collected can be utilized for individual awareness, where people can keep track of their surroundings individually.On a larger scale, the system can be utilized for smart city, environmental, and health studies, as it provides continuous location-based air quality information.The methodology can be utilized to create low-cost, portable, and scalable solutions to bridge the gap between conventional large-scale monitoring stations and individual-level needs.



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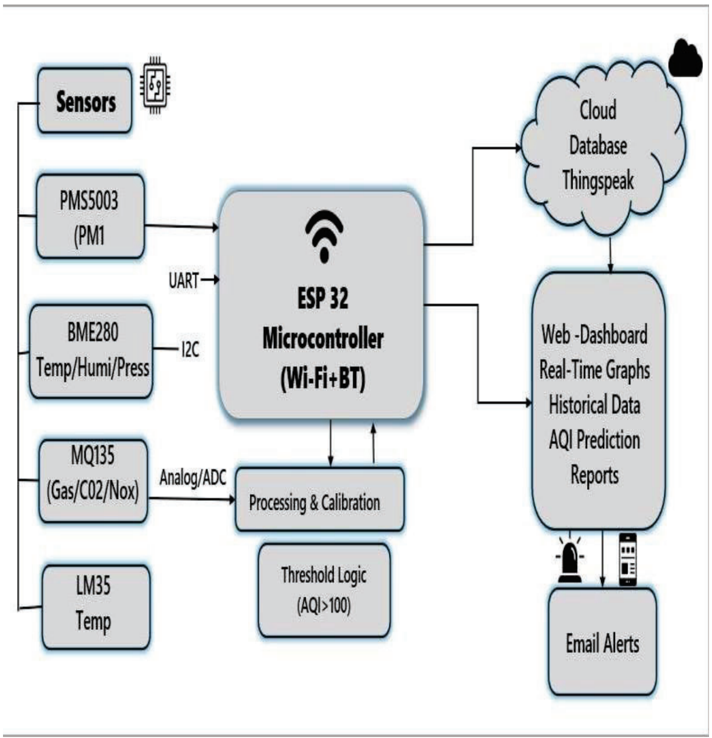


**Fig .1 (Block Diagram)**

## V.RESULTS AND DISCUSSION:

The proposed system was successfully implemented and tested in different environmental conditions; the resulting prototype included an ESP32 Microcontroller along with PMS5003, MQ135 and BME280 Sensors, which allowed for real-time air-quality measurement. This is an example of the hardware implementation is showed in Fig. 2.

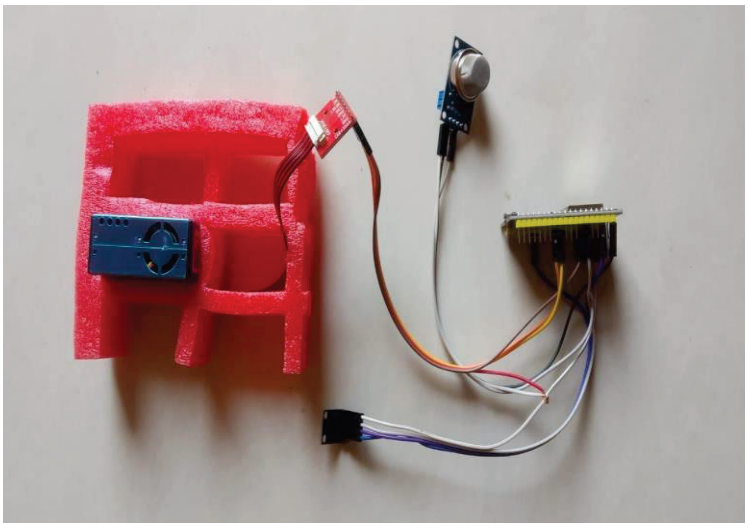

***Fig. 2. Implemented Hardware Prototype of IoT-Based Air Quality Monitoring System***

The Air Quality Index (AQI) gives us an indication of how well (or poorly) the air is based on the amount of pollutants in it. In the system being developed, air quality was rated as either Good, Moderate, Unhealthy, Very Unhealthy, or Hazardous based on recognized criteria for air quality. The classification of air quality will inform consumers about how the air quality may impact their health as pollution increases.To measure particulate matter concentration, the PMS5003 sensor was utilized; to measure harmful gases ($CO_2$ and NOx), the MQ135 sensor was utilized. The information collected from these sensors was sent to the ESP32 microcontroller for processing, and from there comparisons were made against established thresholds for the purpose of determining which AQI category was appropriate.

| AQI Range | Category | Health Effect |
|---|---|---|
| 0–50 | Good | Clean and healthy air quality |
| 51–100 | Moderate | Acceptable air quality with slight pollution |
| 101–150 | Unhealthy for Sensitive Groups | Respiratory discomfort for sensitive people |
| 151–200 | Unhealthy | Poor air quality affecting general population |
| 201–300 | Very Unhealthy | Serious respiratory health effects |
| 301+ | Hazardous | Severe pollution and dangerous conditions |

***Table 1. Air Quality Index (AQI) Classification***

Continuously monitored environmental parameters included the concentration of PM2.5, gas measurements, temperature and humidity levels, and atmosphere pressure. Sensor information was processed using an ESP32 microcontroller sent via Wi-Fi to the ThingSpeak cloud platform. The cloud-based dashboard provides graphical The data collected from the sensor was sent to the cloud platform, and the data was stored and displayed in a graphical format. This helps users understand the trends and changes in air quality over time.The results obtained from the project prove that the system can be used for accurate and precise monitoring of air quality and generation of alerts in real time. The use of multiple sensors also helps improve the overall accuracy and effectiveness of the system, as it allows for overall environmental analysis. However, slight differences in sensor values were obtained due to environmental conditions and sensor calibration.The system proves to be a cost-effective and efficient solution for monitoring and analyzing air quality in real time, and it can be implemented for individual and smart city usecases.


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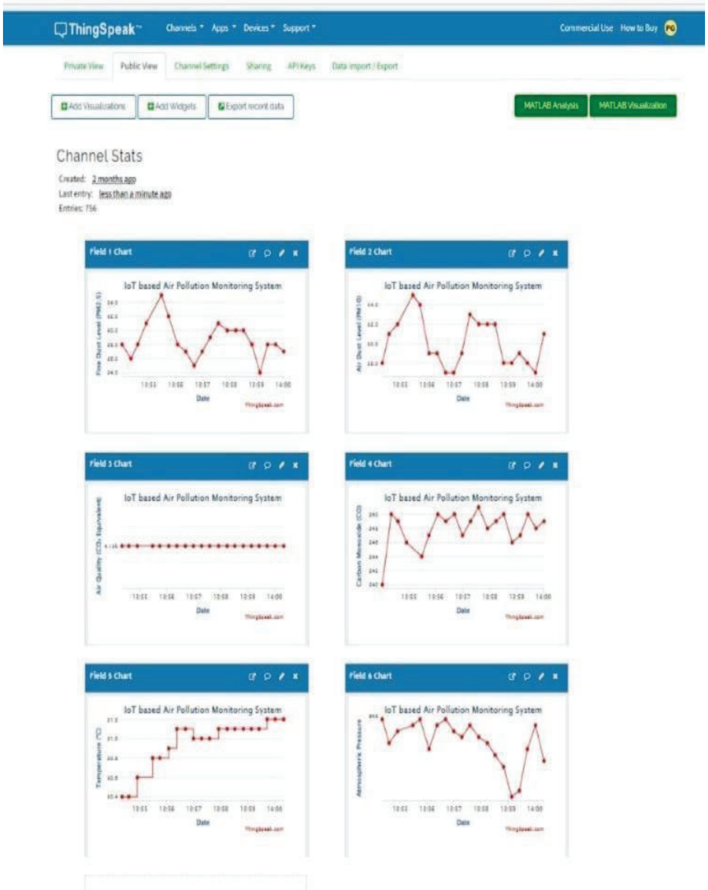


FIG. 3. REAL-TIME SENSOR DATA VISUALIZATION ON THINGSPEAK CLOUD PLATFORM

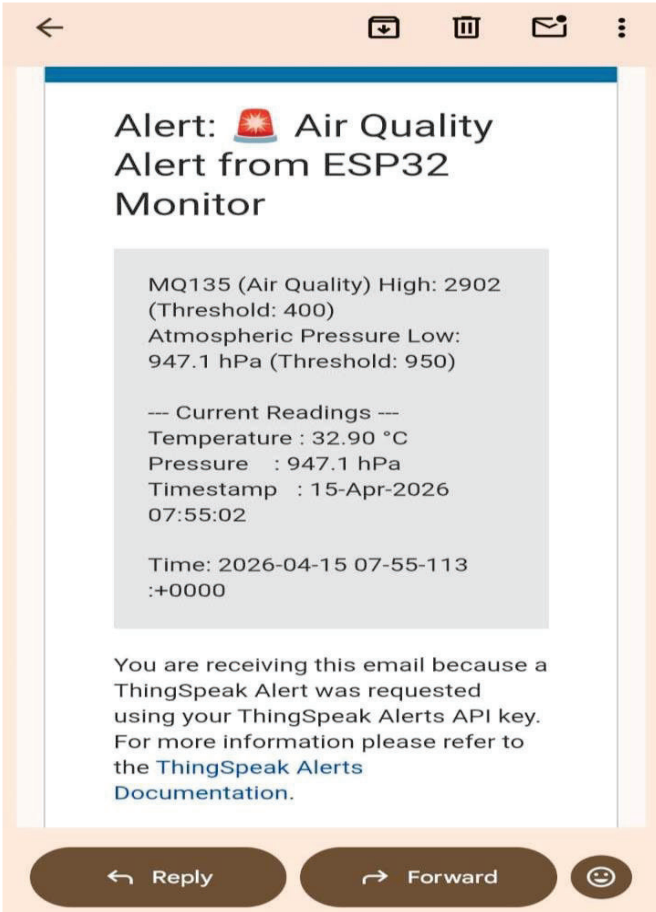


FIG. 4. EMAIL ALERT GENERATED DURING HAZARDOUS AIR QUALITY CONDITION

Data that was monitored was sorted based on pre-defined thresholds into different AQI categories such as Good, Moderate, and Poor. When ambient air quality conditions were close to being negligible (i.e., good ambient air quality), the system displayed a status of “GoodAirQuality”; when there were moderate pollution levels present (i.e. toxic air), the system displayed an status of “ModerateAirQuality.” However, the MQ135 sensor will detect the occurrence of high ambient gasoline concentrations through its gas concentration detection features and generate warning emails when there is a dangerous level of pollutants present in the air.

Through the use of the ThingSpeak cloud service, an email based alerting system was developed and successfully implemented. If there is a certain amount of pollution present and it exceeds the threshold limits predetermined, this system automatically generates warning emails to notify users that there are hazardous pollutants present. The generated alerts are displayed in Fig. 4

## VI.CONCLUSION

Developed as an IoT-based Air Quality Monitoring and Alert System, this technology monitors various aspects of how our environment operates. It does so by utilizing an ESP32 microcontroller as its main processor. Several sensors, including PMS5003 (detects particulate matter), BME280 (detects temperature and humidity), and MQ135 (detects harmful gases), send data about those aspects to the cloud via the ThingSpeak cloud platform (https://thingspeak.com). The data presented in the cloud allows for visualization and exploration of trends over time, which will enable users to monitor air quality from any Internet- connected location. The project also utilizes alert system so that users will be given notice when pollution levels exceed established hazardous levels; therefore, they will be able to take preventative measures or smart living conditions based on the air quality monitored. This project is an example of how IoT technology can be used in smart city development and monitoring the environment. Also, it is a compact, energy-efficient, and cost-effective solution that can aid with the issues of air pollution and help create smart, healthy living environments



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## VII.FUTURE SCOPE

The proposed Air Quality Monitoring and Alert System using the Internet of Things (IoT) can be improved by incorporating Machine Learning (ML) and Artificial Intelligence (AI) methods in order to forecast the future state of pollution, as well as provide smart and historical analysis of the environment. By analyzing data from the prior collecting of data in the environment, the system would be able to recognize pollution trends and ultimately provide future air quality predictions which can thus allow the authorities or the general public to take cautionary measures before the air quality becomes unhealthy.There also exists an opportunity to improve the system with the creation of a user-friendly mobile app and web-based dashboard to view and monitor all real-time data. Users would be able to view real-time environmental data and reports in the form of visually-appealing graphs and receive alert notifications via either/or smartphone and computer, from any place on the planet. In addition, new features will be introduced such as Audio Alert Notifications, GPS Location Monitoring, and Instant Notification Messaging to try and increase overall convenience to the user and to the efficiency of the system as a whole.One more potential enhancement of the air quality monitoring system, to be built now within the Framework of Smart Cities, will ultimately enable an extensive network of ten or more sensor nodes distributed through multiple areas; analyzing multiple sample points that can affect air quality. In addition, all collected data will be centrally housed within a cloud-based data platform for monitoring air quality within urban/ residential areas, as well as within industrial areas, by providing key features for use by the Governmental Authorities/ Agencies and Environmental Protection Agencies.

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