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IOT based Real-Time Air Pollution Monitoring and Alerting System

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ABSTRACT: Air pollution poses significant challenges to environmental sustainability, public health, and urban development. This IOT Based Real-Time Air Pollution Monitoring and Alerting System is a sophisticated solution designed to continuously monitor and analyze air quality across various environments and provides alert to the people(users). This system utilizes advanced sensors to detect and measure the concentration of harmful pollutants such as particulate matter, carbon monoxide (CO), nitrogen dioxide (NO2), Sulphur dioxide (SO2), and ozone (O3). The sensors ESP8266, MQ135 sensor, DHT11 sensor plays a vital role in this project for providing the real time data values of the components present in the air. By collecting real-time data, the system enables the identification of pollution sources, trends, and hotspots. The system supports government agencies in enforcing environmental regulations and helps urban planners design smarter cities with reduced pollution levels.

KEYWORDS: Air pollution, IOT, Real-time.

I. INTRODUCTION

With the rapid pace of urbanization and industrialization, air pollution has become one of the most pressing environmental and public health challenges globally. Poor air quality leads to severe health issues such as respiratory diseases, cardiovascular problems, and even premature deaths. To address this growing concern, we have proposed an idea to create IOT Based Real-Time Air Pollution Monitoring and Alerting System.

The IoT-Based Real-Time Air Pollution Monitoring and Alerting System leverages the power of interconnected devices and sensors to continuously monitor air quality. These sensors detect various pollutants, including particulate matter (PM2.5, PM10), carbon dioxide (CO2), nitrogen dioxide (NO2), and other harmful gases. The collected data is transmitted to cloud-based platforms for real-time analysis, allowing users to monitor air quality trends and receive immediate alerts when pollution levels exceed safe thresholds.

This system not only provides real-time insights but also plays a crucial role in raising awareness, supporting governmental and environmental agencies in taking timely action, and helping individuals make informed decisions about their exposure to polluted environments. By integrating IoT with environmental monitoring, it offers an efficient and scalable solution to safeguard public health and improve air quality standards.

II. OVERVIEW

An IoT-based real-time air pollution monitoring and alerting system leverages the power of sensors, the Internet of Things (IoT), and cloud computing to continuously monitor air quality and notify users when pollution levels exceed safe thresholds. This system utilizes advanced sensors to detect and measure the concentration of harmful pollutants such as particulate matter, carbon monoxide (CO), nitrogen dioxide (NO2), Sulphur dioxide (SO2), and ozone (O3). The sensors ESP8266 sensor, MQ135 sensor, DHT11 sensor plays a vital role in this project for providing the real time data values of the components present in the air, which are then connected to a microcontroller or single-board computer, such as an Arduino.

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These devices collect the data from the sensors and transmit it to a cloud platform using Wi-Fi or GSM(SIM) networks. In the cloud, the data is processed and analyzed in real time, and the results are displayed on a user interface, such as a mobile app or web dashboard. The system's alerting mechanism, which can use SMS, email, or mobile notifications, is crucial in enabling users—whether individuals or city officials—to take immediate action when air quality becomes hazardous. This technology is particularly useful in urban areas where pollution levels can fluctuate, or in industrial zones to monitor emissions and comply with environmental regulations.

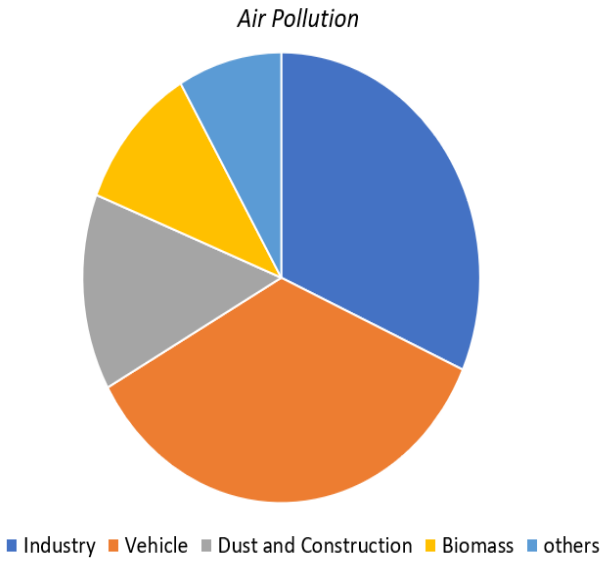

Fig 1: Air Pollution causes

III. COMPONENTS

1. MQ135: The MQ135 sensor is a gas sensor commonly used to detect a variety of gases, such as ammonia (NH3), nitrogen oxide (NOx), alcohol, benzene, smoke, and carbon dioxide (CO2). It is widely utilized in air quality monitoring systems due to its ability to measure concentrations of these gases in the air.
2. DHT11: The DHT11 sensor is a low-cost digital sensor used to measure temperature and humidity. It provides calibrated digital output and is widely used in weather monitoring and environmental projects. The sensor has a temperature range of 0–50°C and a humidity range of 20–90% with moderate accuracy.

SOFTWARE SPECIFICATION:

1. Arduino IDE
2. Programming Language - C Language

IV. EXISTING SYSTEM

There are several systems were existing to provide real-time monitorization of air pollution. The existing system might be in a feature of providing the environmental protection sector with an efficient and easy-to-use technological solution that aims to monitor air pollutants by applying an ICT-based system to remotely monitor air pollution variables that affect quality of life of living beings. Many AI - based monitoring system was existing to provide the real time monitorization of air pollution. The existing systems mostly concentrate only on monitorization rather than providing the awareness on the monitorization.

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V. PROPOSED SYSTEM

A. ABBREVIATIONS AND ACRONYMS

a. IOT - Internet of Things
b. MQ135 sensor - Metal Oxide Semiconductor Quasi-conductive 135 sensors
c. DHT11 sensor - Digital Humidity and Temperature 11 sensor
d. CO - Carbon monoxide
e. NO2 - Nitrogen dioxide
f. SO2 - Sulphur dioxide
g. O3 – Ozone

B. OBJECTIVE

The Objective of an IoT-based Real-Time Air Pollution Monitoring and Alerting System is to monitor air quality continuously and provide real-time updates about the levels of pollutants in the environment. The system typically uses a network of sensors to measure various air quality parameters, such as:

- Concentration on pollutants: This includes gases like CO2, CO, NO2, SO2.-
- Temperature and humidity: To understand how environmental factors influence pollution levels.
- Real-time air quality monitoring: The system collects data from multiple sensors, providing immediate insight into air pollution levels at specific locations.
- Alerting system: If pollution levels exceed a predefined threshold, the system triggers alerts via mobile apps, SMS, or emails, informing people and authorities to take necessary actions.
- Decision-making support: This data aids environmental agencies in implementing air quality improvement measures, such as traffic control, factory emission limits, and public health advisories.

C. METHODOLOGY

The IoT-Based Real-Time Air Pollution Monitoring and Alerting System is a comprehensive solution designed to enhance environmental monitoring, data analytics, and public awareness through the use of advanced IoT technologies. The scope of the project is as follows:

- **Hardware Design and Integration**

Sensor Selection: Use an array of air quality sensors (e.g., MQ135) to measure a wide range of pollutants. Temperature and humidity sensors to capture environmental conditions that affect air pollution levels.
Sensor Evaluation: Implement dynamic Evaluation mechanisms to adjust sensor accuracy over time, ensuring precise and reliable data readings. Using MQ135 & DHT11 sensors for detection monitoring.

- **Wireless Communication and Networking**: communication Protocols: Using 12C converter, which is a serial communication protocol commonly used in embedded systems, sensors, and IoT devices for short-distance communication between microcontrollers and peripherals.

- **Real-time Monitoring and Visualization:**

Dashboard Development:
Develop inherent web-based dashboards that visualize air pollution levels in real time. Using data visualization techniques is used to visualize the data.

- **Alert and Notification System:**

Alarm:
Alarm system is implemented to provide a alert consciousness to people.
Notification System:
Notify the people about the air quality and pollution levels.

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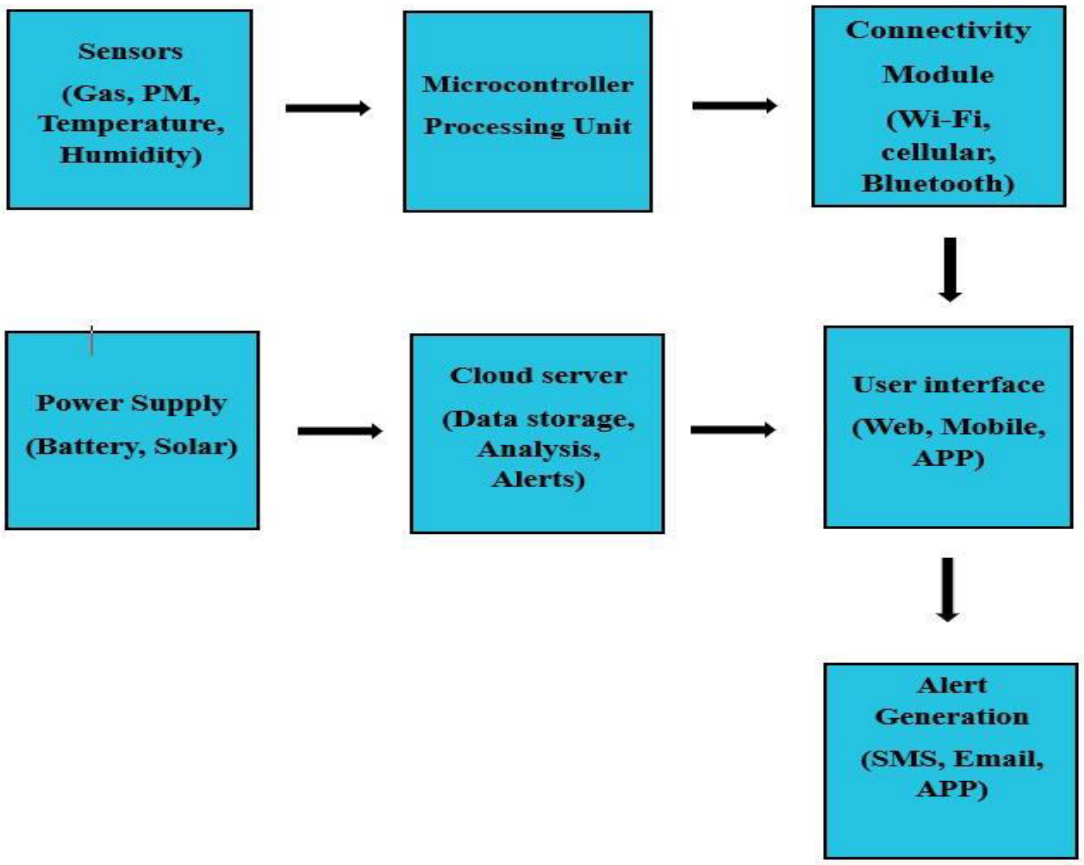

Fig 2: System modules

VI. IMPLEMENTATION OF PROJECT

Air pollution has become one of the most pressing environmental and public health challenges globally. Poor air quality leads to severe health issues such as respiratory diseases, cardiovascular problems, and even premature deaths. To address this serious issue, we have proposed an idea to implement IOT Based Real-Time Air Pollution Monitoring and Alerting System. The IoT-Based Real-Time Air Pollution Monitoring and Alerting System leverages the power of interconnected devices and sensors to continuously monitor air quality. These sensors detect various pollutants, including, carbon dioxide (CO2), nitrogen dioxide (NO2), and other harmful gases.

The collected data is transmitted to cloud-based platforms for real-time analysis, allowing users to monitor air quality trends and receive immediate alerts when pollution levels exceed safe thresholds. This system not only provides real-time insights but also plays a crucial role in raising awareness, supporting governmental and environmental agencies in taking timely action, and helping individuals make informed decisions about their exposure to polluted environments. By integrating IoT with environmental monitoring, it offers an efficient and scalable solution to safeguard public health and improve air quality standards.

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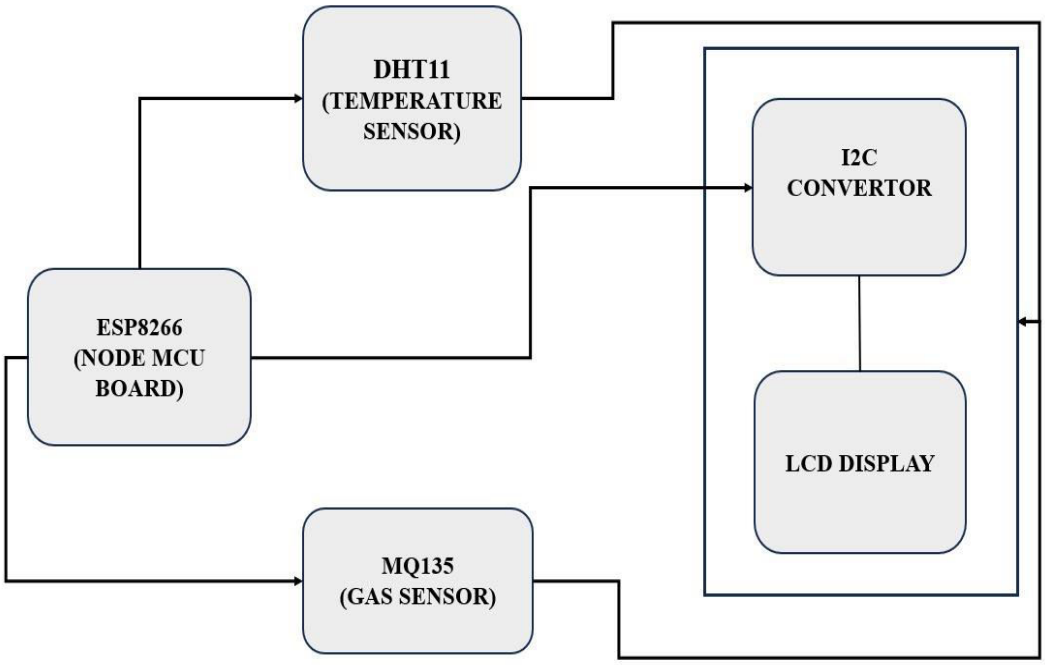

Fig 3: Architecture diagram

REAL-TIME STATISTICAL DATA:

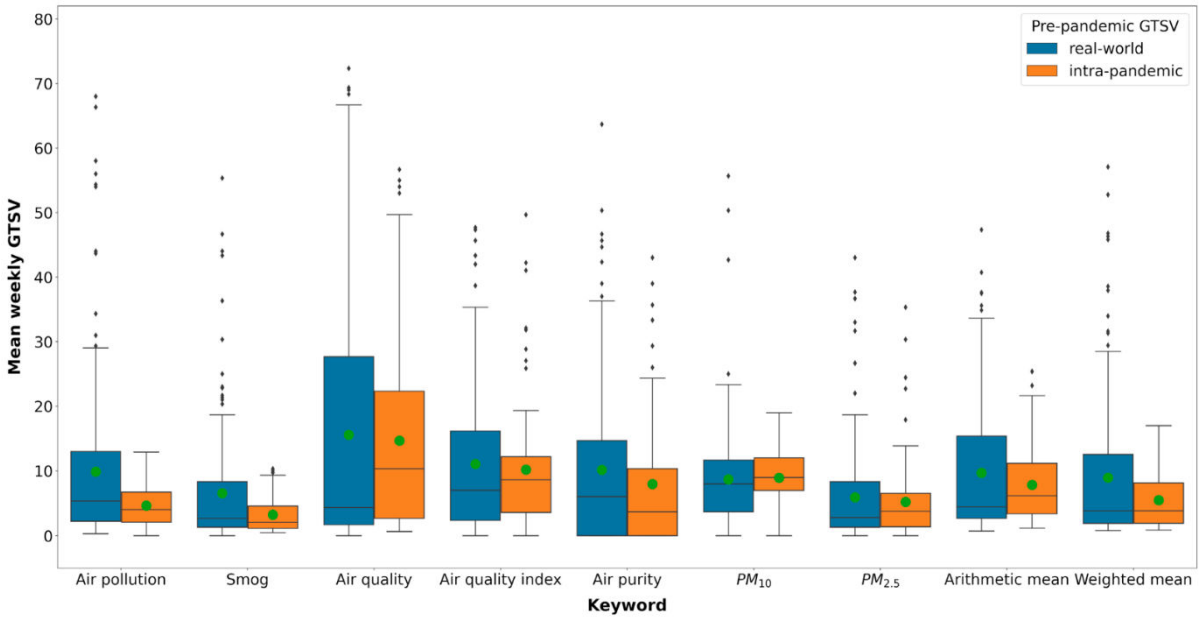

Fig 4: Air Pollution rate

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Air pollution data collected from an IoT-based Real-Time Air Pollution Monitoring and Alerting System reveals significant variations in air quality across different locations. For instance, at Location A, measurements taken on September 1, 2024, indicated PM2.5 levels reached a peak of 70 µg/m³ around noon, corresponding to an Air Quality Index (AQI) of 165, which classifies the air quality as "Unhealthy." In comparison, Location B displayed generally better air quality, with PM2.5 levels remaining below 35 µg/m³ during the same period, leading to an AQI rating that fluctuated between "Good" and "Moderate." Location C exhibited alarming pollution levels, with PM2.5 consistently over 85 µg/m³, resulting in an AQI above 200, categorized as Hazardous.

From the data provided, there is a clear upward trend in the levels of air pollutants over the five years. PM2.5 levels increased from an average of 45 µg/m³ in 2020 to 75 µg/m³ in 2024, indicating a worsening air quality situation. Similarly, PM10, CO, NO_2, and SO_2 levels have also shown consistent increases. The AQI classification shifted from "Good" in 2020 to "Unhealthy" by 2024, highlighting the growing concern regarding air pollution and its potential health impacts. This trend underscores the need for effective air quality management and intervention strategies to mitigate pollution levels and protect public health.

VII. ADVANTAGE

- **Real-time data:** IoT-based air pollution monitoring systems provide instant information about air quality, helping people stay updated on current pollution levels.
- **Early warnings:** They can send alerts when pollution reaches dangerous levels, allowing individuals to take precautions.
- **Better health protection**: With timely alerts, people can avoid exposure to harmful pollutants, reducing the risk of respiratory and other health issues.
- **Government and public planning:** Authorities can use the data to create policies and take action to reduce pollution.
- **Automated reporting:** It automatically collects and processes data, making it easier to track air quality over time.
- **Environmental awareness:** Continuous monitoring helps raise awareness about pollution and encourages eco-friendly behavior.

VIII. FUTURE WORK

- The future scope of an IoT-based air pollution monitoring system is vast, with potential growth in smart city integration, AI-driven analytics, health applications, and policy support.
- Ongoing advancements in sensor technology, IoT connectivity, and data processing will play key roles in shaping the evolution of such systems, ultimately improving public health and contributing to cleaner, more sustainable environments worldwide.
- As the system scales to cover broader areas, including rural regions and developing countries, it could offer affordable, real-time air quality monitoring globally, improving public health and supporting sustainable development.

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