Ahmedabad University

Project Report-1
Group-5
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Chapter 01

- Introduction

Air pollution has become one of the most pressing environmental and health issues of the 21st century, mainly due to industrial emissions, vehicular exhaust, and urbanization. While eliminating air pollution entirely may seem challenging, reducing its harmful effects through continuous monitoring and preventive measures is achievable. Many densely populated cities, particularly in developing nations, face severe air quality deterioration without adequate monitoring systems in place. This leads to respiratory illnesses, cardiovascular problems, and long-term health risks for the population. To address this growing concern, a system is being developed that simplifies air quality monitoring and classification, focusing on essential parameters such as particulate matter (PM2.5 and PM10), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and temperature/humidity levels.

The advancement of the Internet of Things (IoT) has introduced new possibilities for real-time environmental data collection, analysis, and remote monitoring. This technology enables users to track air quality trends in real-time from any location. The proposed system will consist of multiple nodes, each equipped with an array of sensors, deployed across urban and industrial regions. These sensors will continuously collect data on air pollutants and wirelessly transmit it to a central server via IoT communication protocols. If pollutant levels exceed safe thresholds, an automated alert will be triggered to notify concerned authorities and residents. The collected data will also be analyzed using classification algorithms to categorize air quality into health-based categories, aiding decision-makers in implementing mitigation strategies.

Different sensors play a critical role in monitoring various aspects of air quality. For instance, a dust sensor measures PM2.5 and PM10 concentrations, a gas sensor detects CO and NO_2, while ozone sensors track O_3 levels. A DHT11 or DHT22 sensor measures temperature and humidity, as these factors influence pollutant dispersion. An Arduino or ESP32 microcontroller collects the sensor data, and with the help of an ESP8266/LoRa communication module, the information is transmitted to a cloud platform for visualization. The system classifies air quality levels—such as “Good,” “Moderate,” or “Hazardous”—based on Air Quality Index (AQI) standards, making the data easy to interpret for both researchers and the general public.

Air pollution is particularly concerning in countries like India and China, where rapid industrialization and high vehicle density worsen the situation. Managing air quality and ensuring a safe environment have become urgent priorities. Traditional air monitoring methods are limited to large, expensive stations that cover only select locations, leaving gaps in real-time, widespread monitoring. This limitation often results in delayed detection of hazardous pollution spikes, increasing health risks. IoT-based air quality monitoring offers a more scalable and cost-effective solution.

The proposed system aims to provide real-time pollutant data, generate historical trend analyses, and issue early warnings for hazardous conditions. By leveraging IoT and advanced classification techniques, the system not only detects pollutant levels but also categorizes air quality into actionable classes aligned with global AQI standards. This helps authorities take proactive measures, such as traffic control, public advisories, or industrial emission management, ultimately contributing to healthier living conditions.

Problem Definition

Air is a vital natural resource, yet its quality is rapidly deteriorating due to industrialization, urbanization, and vehicular emissions. Unfortunately, air pollution has become one of the most critical global concerns in recent decades, with hazardous gases and fine particulate matter contaminating the atmosphere. While completely eradicating air pollution is impossible, it is essential to minimize its harmful impacts. In many developing nations, people are exposed daily to unsafe air quality without proper monitoring or warnings, which leads to severe health risks. Air pollution occurs when harmful gases, chemical particles, or biological matter contaminate the atmosphere, reducing its purity and threatening the well-being of living organisms. Polluted air contributes to the death of plants and animals, disrupts ecosystems, and accelerates climate change. Moreover, exposure to polluted air causes respiratory diseases such as asthma, bronchitis, and lung cancer, leading to approximately 7 million premature deaths globally every year, according to the World Health Organization (WHO).

Motivation

The suggested system enhances air quality monitoring by introducing more advanced and efficient approaches. It emphasizes increasing the frequency of data collection, integrating more accurate and durable sensors, and expanding the range of air pollutants being measured. This project aims to create a streamlined process for gathering atmospheric data, transmitting it wirelessly, and storing it securely. A key feature is the ability to archive all collected data, which can serve as a valuable resource for future research and analysis. This will enable better tracking of pollution patterns and provide deeper insights into how air quality fluctuates across different times and locations.

Chapter 02

Market Survey or Literature Survey of Current Products

Market Size:

The global air quality monitoring market is expanding rapidly due to increasing concerns about urban air pollution, rising health issues caused by poor air quality, and stricter government regulations. According to multiple market research reports, the industry is expected to grow at a significant CAGR in the coming years. The rising adoption of IoT-enabled devices, combined with the demand for real-time monitoring, is driving the growth of this market. Additionally, the need for low-cost, portable solutions is creating opportunities for innovative IoT-based air monitoring systems.

Relevant Products:

Given the precise needs specified in our proposal, a variety of items apply to the market:

1. IoT-based Air Quality Monitoring Systems

Features: These systems integrate sensors to measure air quality parameters such as PM2.5, PM10, CO_2, CO, SO_2, NO_2, O_3, temperature, and humidity. They utilize IoT technology to transmit real-time data to a cloud platform for monitoring, visualization, and analysis.
Examples: Companies like Aeroqual, TSI Incorporated, and Kaiterra provide IoT-based air quality monitoring systems for urban, industrial, and residential use.

2. Wireless Air Quality Sensors

Features: Compact and power-efficient, these sensors can be deployed in multiple locations, even in remote or high-density urban areas. They wirelessly send pollution data, making them suitable for long-term and large-scale monitoring.
Examples: Companies such as AirVisual (IQAir), Spec Sensors, and Sensirion offer wireless air quality sensors with capabilities for detecting particulate matter and harmful gases.

3. Air Quality Monitoring Software Platforms

Features: Software platforms collect, analyze, and visualize air pollution data. They support AQI classification, trend forecasting, and regulatory compliance checks. They also provide dashboards and mobile applications for public awareness and decision-making.
Examples: BreezoMeter, Airly, and Clarity Movement Co. provide software solutions tailored for real-time air quality tracking.

Market Trends:

- **Growing IoT adoption:** Integration of IoT and AI technologies is revolutionizing air quality monitoring by enabling real-time pollutant detection and AQI classification.

- **Focus on portable and remote monitoring:** Compact wireless sensors and cloud-based platforms are increasingly popular for urban, residential, and industrial monitoring.

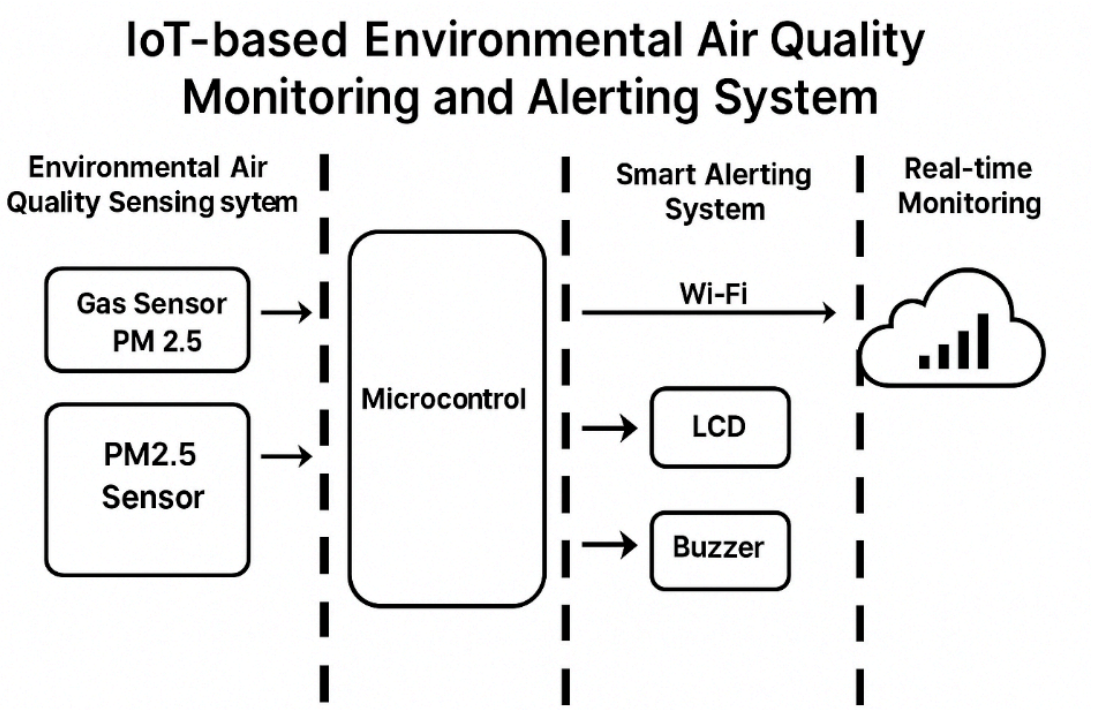
- **Advances in sensor technology:** Development of more accurate, low-cost, and energy-efficient sensors is expanding the possibilities for continuous air quality tracking.

- **Public health awareness and regulation:** Governments and organizations are pushing stricter emission norms, while the public is demanding transparent, data-driven air quality insights.

- **AI-based classification:** Advanced algorithms are being used to classify pollution levels into health-based categories, allowing better decision-making and early warnings.

Chapter 03

Block Diagram and Explanation



1. Environmental Air Quality Sensing System

This subsystem is responsible for **detecting and measuring pollutants** in the air:

- **Gas Sensor MQ135**
    - Detects harmful gases such as **CO_2, NH_3, benzene, NOx, and smoke**.
    - Provides an analog voltage signal proportional to the gas concentration.
- **Particulate Matter Sensor (PM2.5 / PM10)**
    - Measures the concentration of fine dust particles suspended in the air.

- PM2.5 = Particles ≤ 2.5 micrometers, highly dangerous as they penetrate deep into lungs.
- PM10 = Particles ≤ 10 micrometers, also harmful to respiratory health.
- Provides digital/analog output depending on sensor model (e.g., SDS011, PMS5003).

2. Processing and Smart Alerting System

- **Raspberry Pi 3 Model B**
  - Acts as the main processing unit.
  - Collects readings from MQ135, PM sensor, and DHT sensor.
  - Compares data with standard Air Quality Index (AQI) thresholds.
  - Performs classification of air quality levels (e.g., Good, Moderate, Poor, Hazardous).
  - Connects to Wi-Fi for uploading data to the cloud.
- **LCD Display**
  - Shows real-time readings of gas concentration, PM2.5/PM10 levels, temperature, and humidity.
  - Can also display the classified AQI category.
- **Buzzer**
  - Gives an alert/alarm if air quality crosses hazardous levels.
  - Acts as a local safety warning system.

3. Real-time Monitoring System

- **Wi-Fi Communication**

    - Enables Raspberry Pi to upload sensor data to the cloud or real-time database.

- **Real-time Database / Cloud Storage**
    - Stores continuous data on air quality for long-term monitoring and analysis.
    - Can be visualized later for trend analysis or reports.

Inputs to the System

- Air quality parameters from the environment:
    - Gas concentrations (CO_2, NH_3, NOx, smoke, etc.) → from MQ135
    - Particulate matter levels (PM2.5 / PM10) → from PM sensor
    - Temperature and Humidity → from DHT11/DHT22 sensor

These are the raw environmental inputs captured by the sensing system.

Outputs of the System

- Real-time Display of air quality parameters and their AQI classification (e.g., Good, Moderate, Poor, Hazardous) on LCD.
- Alerts via Buzzer if pollutants exceed safe thresholds.
- Data Upload to Cloud/Database for storage, analysis, and visualization of long-term trends.