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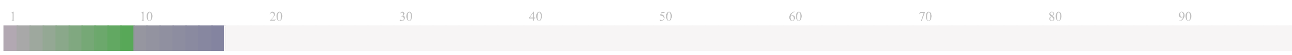

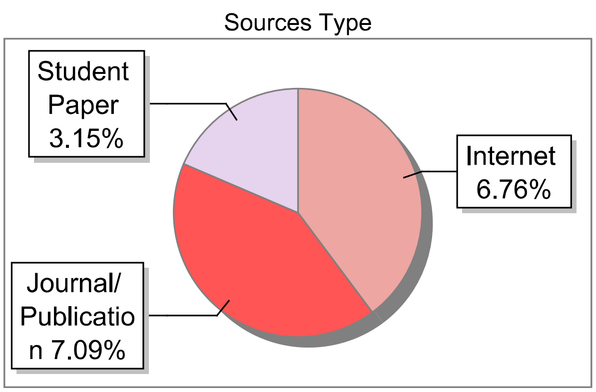

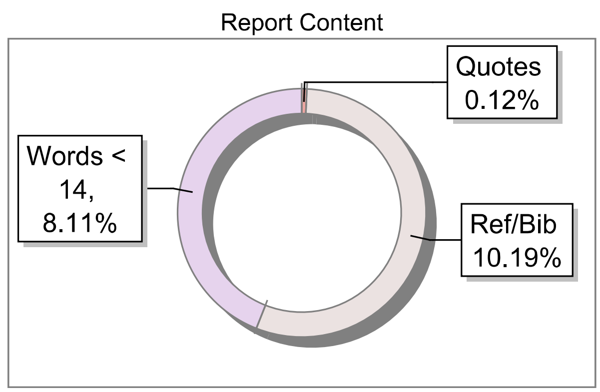

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38	moam.info	<1	Internet Data
39	theses.hal.science	<1	Publication
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41	alameenedu.co.in	<1	Publication
43	A Cost Model for Air Quality Monitoring Systems by Hickey-1971	<1	Publication
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Visvesvaraya Technological University

Belagavi

A Mini Project Report

on

REAL-TIME AIR QUALITY MONITORING AND ALERTING SYSTEM

Submitted by

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In partial fulfilment for the award of the

degree of

BACHELOR OF ENGINEERING

IN

ELECTRONICS AND COMMUNICATION ENGINEERING

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New Horizon Knowledge Park, Ring Road, Marathalli
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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

Certified that the Mini project entitled "Real-Time Air Quality Monitoring and Alerting system" is carried out by Mr. R PRASEN AKHIL BABU bearing USN: 1NH22EC131 and Mr. S V N MAHENDRA REDDY bearing USN: 1NH22EC180, bonafide students of NHCE, Bengaluru in partial fulfilment for the award of Bachelor of Engineering in Electronics and Communication of the Visvesvaraya Technological University, Belagavi during the year 2023-24. It is certified that all corrections and suggestions indicated for Internal Assessment have been incorporated in the report deposited in the department library. The mini project report has been approved as it satisfies the academic requirements in respect of the mini project work prescribed for the said degree.

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ABSTRACT

A real-time air quality monitoring and alerting system without Wi-Fi relies on advanced sensor technology to measure key air pollutants like particulate matter(PM2.5, PM10), carbon dioxide, volatile organic compounds. These sensors collect data continuously and transmit it to a local microcontroller or embedded system for processing. The system uses low-power communication technologies, such as LoRa or Zigbee, to send alerts to users without relying on Wi-Fi. In the absence of internet connectivity, the device can store data locally and active alarms via audible or visual indicators when pollutant levels exceed predefined thresholds. This ensure immediate action can be taken to protect public health. The data can be analyzed periodically through an offline system or transferred to a central database via physical connections for further analysis and long-term monitoring. The system also supports integration with external devices like air purifiers or ventilation systems, Which can be activated automatically when air quality deteriorates. The deployment of such systems in remote areas, Where internet infrastructure is scarce, ensures wide-ranging environmental monitoring capabilities. By enabling localized decision making , The system empowers individuals or communities to take prompt action without the need for internet access. Such real-time monitoring is crucial for improving air quality awareness and mitigating the health risks associated wit pollution. Furthermore, this approach ensures resilience in environments with absent Wi-Fi infrastructure, making it a valuable tool for disaster response and proactive environmental management.

This abstract succinctly describes the purpose, methodology, and potential impact of the project.

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CHAPTER 1
INTRODUCTION

A real-time air quality monitoring and alerting system is a technological solution, continuously tracking and evaluating the air quality by measuring a variety of pollutants in the atmosphere. The primary aim of the system is to provide timely and accurate information on the levels of air pollution, enabling individuals, businesses, and communities to take prompt action when air quality worsens. Monitoring air quality is necessary for public health, especially in urban areas and industrial zones where the pollution levels may be high, and harmful pollutants such as particulate matter (PM2.5, PM10), carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), and volatile organic compounds (VOCs) can cause serious health issues, including respiratory diseases, cardiovascular problems, and other environmental hazards.

These systems use various sensors to detect these pollutants and give live feedback through alerts or notifications. These systems can be installed in homes, offices, factories, public spaces, and even rural or remote areas where traditional air quality monitoring infrastructure may be lacking. Many systems include alert mechanisms, such as audible buzzers or visual indicators (LED lights), that notify users when pollutant concentrations exceed predefined thresholds, allowing for swift corrective actions. Microcontrollers and other electronic components allow users to monitor air quality in real-time, gain insights into pollution trends, and take proactive measures for better air quality management.

A sun-tracking solar panel system is designed to follow the sun’s path across the sky throughout the day. This tracking maximizes the amount of sunlight the panels capture, which can significantly increase their efficiency compared to fixed-panel systems.

1. Mechanism

a. **Air Quality Sensor(MQ135)**: Air quality sensor is the most important and first component in the monitoring system. MQ135 sensor is used for detecting various gases, ammonia, carbon dioxide, smoke, and other VOCs in the air.

Working: It consists of a metal oxide semiconductor material that reacts with gases in the air. When the smoke is interact with the sensor, the chemical reaction occurring on the MOS surface causes it to change its resistance.

b. **Microcontroller(Arduino uno)**: The microcontroller, an Arduino Uno is where the control unit resides where in the data coming from the sensor is processed and thus decisions are made. From the analog signals received by the sensors, it transmits them as digital so that it can be well understood and acted upon.

Working:

Data Acquisition: The Arduino cintinously reads the analog signals(gas concentrations) from the MQ135 sensor.

Processing: The microcontroller processes the sensors data, comparing it against predefined threshold values for specific pollutants.

c. **Resistors and Potentiometer:** These are used to regulate current, voltage, and sensitivity of the system. Resistors prevent excessive current from damaging sensitive components like the MQ135, LEDs, or the Arduino. A potentiometer helps in sensitivity adjustment of the sensors. The MQ135 sensor may be calibrated to be sensitive to some particular gases by adjusting its resistance or changing the threshold that will make an alert be triggered.

d. **Power Output:** By maintaining a perpendicular angle to the sun's rays, sun tracking panels can increase the amount of solar energy captured, potentially boosting electricity production by 20-40% compared to fixed systems.

2. Benefits

a. Improved Public Health

Early Warning of Pollution Peaks: Real-time monitoring helps identify sudden spikes in air pollutants, such as PM2.5, PM10, ozone, carbon monoxide, and nitrogen dioxide. Alerts can warn people, especially vulnerable populations (children, elderly, people with respiratory conditions), to limit outdoor activities, reducing exposure to harmful pollutants.

Chronic Health Monitoring: Consistent monitoring allows for tracking long-term air quality trends, helping to address chronic health issues related to poor air quality, such as asthma, heart disease, and respiratory disorders.

b. Environmental Protection

Informed Decision-Making: Data from real-time air quality systems supports informed decisions for regulating industrial emissions, urban planning, transportation policies, and conservation efforts, helping to mitigate the environmental impact of pollution.

Pollution Source Identification: Continuous monitoring helps pinpoint areas with high pollution levels, enabling authorities to track sources (e.g., traffic, industrial emissions) and take corrective action.

c. Enhanced Public Awareness

Public Access to Data: Real-time air quality information, often accessible via apps or websites, keeps the public informed about the state of the environment. This transparency encourages people to take individual actions, such as reducing vehicle use, using public transport, or reducing energy consumption.

Informed Community Action: Alerts help communities take immediate action during times of poor air quality, such as organizing health checks, limiting outdoor events, or deploying air purifiers in buildings.

d. Regulatory Compliance and Policy Development

Compliance with Air Quality Standards: Monitoring ensures compliance with national and international air quality standards (e.g., WHO guidelines), providing evidence for policy enforcement and adjustments.

Data for Policy Advocacy: Real-time data can be used by environmental organizations and policymakers to advocate for stricter regulations and to push for initiatives like green urban spaces, better waste management, and the promotion of cleaner technologies.

e. Emergency Response and Disaster Management

Responding to Pollutant Emergencies: In cases of hazardous air pollution, such as wildfires or industrial accidents, a real-time alert system can inform citizens, governments, and emergency responders. This allows them to take immediate actions, like issuing evacuation orders or activating public health responses.

Adaptation to Climate Change: Real-time air quality monitoring helps communities adapt to the evolving challenges posed by climate change, including increased incidences of pollution from wildfires, droughts, or storms.

f. Public Health and Environmental Cost Savings

Reducing Health Care Costs: By preventing exposure to harmful pollutants, air quality monitoring reduces the burden on healthcare systems, cutting costs related to treating air pollution-related diseases.

Cost-Effective Monitoring: Real-time systems provide cost-effective ways to track air quality in various locations, replacing expensive manual monitoring methods. This allows for wider coverage without the high cost of traditional methods.

g. Research and Development

Data for Scientific Research: Continuous real-time data provides valuable input for scientific research on air quality and pollution control technologies. This can help improve understanding of pollution sources and develop new solutions to combat air quality issues.

Innovations in Pollution Control: Data from real-time systems supports the development of new innovations in technologies that reduce air pollution, such as low-emission vehicles, smart energy grids, and sustainable urban designs.

h. Economic Benefits

Boosting Tourism and Business: Cities with better air quality can attract more tourists and businesses. Real-time monitoring can help highlight and maintain clean air areas, benefiting local economies

CHAPTER 2

LITERATURE REVIEW

A. IoT-Based Solutions for Environmental Monitoring

Author: Patil, S.,and Kulkarni, S.

Year of Publication: Its Published in the year 2019

Out Comes of the Book: The study talks about the IoT-based solutions in elevating the environmental monitoring systems from hints to enforcement for authors. The authors talk about the interconnected smart sensors that help in real- time data collection, process, and analysis.

B. Alerting Mechanisms for Air Quality Monitoring Systems

Author: Mishra, P.Singh and R.Gupta, A.

Year of Publication: this concept was published in 2021.

Out Comes of the Book: The different alert types involve both audible and visual signals that enable the public to recognize potential health hazards. This paper introduces the various types of alert and suggests how they can be used to make them effective in triggering public awareness and action for public health protection, particularly in areas susceptible to exposure from pollution sources.

C. Real Time Air Quality Monitoring And Alerting System

Autor: Zhao,L Zhang,X and Li,Y.

Year of publication: The Book was published in the year 2018.

Outcomes of the Book: This book provides a compre- hensive guide on real-time air quality control systems, empha- sizing advanced technologies for air pollution detection and the thinking of integrating alerting mechanisms.The authors discuss the challenges of designing efficient systems that can provide accurate data and timely alerts, helping to mitigate the effects of air pollution on vulnerable populations.

D. Low-Cost Sensors for Real-Time Air Quality Monitoring

Author: Liu, H., Chen, J.Wu,Q

year of Publication:

Out Comes of the Book: The development and deploy- ment of low-cost sensors for real-time air quality monitoring are discussed in this paper.

CHAPTER 3
EXISTING SYSTEM

Problem Statement

As urbanization and industrial activities continue to increase, air quality has become a significant concern due to its adverse effects on public health and the environment. Traditional air quality monitoring systems often suffer from limitations such as fixed locations, which provide only localized data and fail to capture the full spatial distribution of pollutants. This can lead to incomplete assessments of pollution sources and variability across different areas. Additionally, current systems may lack the flexibility to adapt to varying environmental conditions and may not provide real-time data for immediate decision-making.

To address these challenges, there is a need for an innovative solution that combines mobility with advanced sensing and data communication technologies to deliver comprehensive, real-time air quality monitoring across diverse environments. The intricacy of current monitoring methods frequently restricts public understanding and participation. Systems that not only supply precise data but also make it easily comprehensible are required to promote environmental consciousness and public awareness. An inventive approach that combines cutting-edge sensor technology, autonomous robotic mobility, and real-time data exchange is required to address these issues.

Detecting Multiple Pollutants: To give a comprehensive picture of air quality, it should be fitted with sensors that can measure a variety of pollutants, such as gases and particle matter. Although there are numerous platforms for real-time air quality monitoring and alerting, the coverage in many areas, especially in developing regions or smaller municipalities with limited resources, cannot be continuous and accurate.

Objective

A. Real-time Air Quality Measurement:

To give quick insights into air pollution levels, continuously monitor and report on important air quality indicators such particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, and volatile organic compounds.

B. Data Collection and Storage

Compile and keep track of air quality data in an organized manner over time to facilitate trend analysis, assessments of the efficacy of pollution management strategies, and research.

By identifying pollution hotspots and comprehending the spatial distribution of contaminants, geospatial mapping of air quality data might help to facilitate targeted responses.

C. Real-time Alerts and Notifications

Notify relevant parties in a timely manner when pollution levels exceed safety criteria, allowing for quick action to safeguard the public's health.

D. Autonomous Navigation

Navigate across different environments on your own to guarantee thorough and effective surveillance without requiring manual relocation.

E. Integration with Other Systems

To improve data utility and assist more comprehensive environmental management initiatives, integrate with current environmental monitoring systems and smart city infrastructure.

Provide an easy-to-use interface for displaying data in the form of maps, graphs, and charts so that complex information may be accessed and used to support well-informed decision-making.

F. Power Efficiency and Longevity

Reduce maintenance requirements and ensure long-term deployment by optimizing power utilization to prolong operating times between charges or refills.

G. Durability and weather Resistance

To ensure dependable performance, build robustly to withstand harsh weather conditions like rain, dust, severe temperatures, and mechanical wear.

H. Scalability and Modularity

Adapt to changing needs and technology breakthroughs by enabling scalable deployment and modular upgrades for extra sensors or functionality.

CHAPTER 4
PROPOSED SYSTEM

This will monitor the real-time quality of air with a sensor network measuring the pollutants including PM2.5, PM10, CO, NO2, and SO2. The system, instead of depending upon Wi-Fi, uses the LoRaWAN Long Range Wide Area Network protocol for low-power, long-range communication. This can particularly come in handy when Wi-Fi is not accessible or less feasible in some areas. For example, remote areas, large rural areas, or industrial sites.

A. **Air Quality Sensors:**

The system will employ low-cost, high-precision air quality sensors to measure various pollutants, including PM2.5 and PM10 for particulate matter. CO (Carbon Monoxide) for harmful gases.NO2 (Nitrogen Dioxide), SO2 (Sulfur Dioxide), and O3 (Ozone) for other critical pollutants. These sensors will be placed at various strategic locations to monitor air quality in real-time.

B. **LoRaWAN for Data Transmission:**

LoRaWAN would be used to transfer the collected data from the sensors to a gateway in the place. While it's suitable for usage in areas with no access to Wi-Fi, as LoRaWAN can transfer signals quite a distance away and its usage consumes little power-an important feature in sensor applications, where these devices usually work for several months to years without their battery replacing. The sensor data would be received at the gateway through LoRaWAN and forwarded to a central processing unit such as a cloud server or a local computer.

C. **Data Processing and Cloud Storage:**

After the data is received using LoRaWAN, it will be processed over a central server. Then, the central server computes the Air Quality Index for each of the pollutants in terms of predefined standards and thresholds. The data will also be put on a cloud server with historical analysis, forecasting as well as access through the web or mobile applications.

D. Alert System:

SMS and Automated Calling: Since Wi-Fi won't be used, alerts will still be sent via GSM-based SMS or automated calling on phone for real-time alerting of users whenever it crosses dangerous thresholds.

Local Display: Besides SMS/phone calls, local LED displays or buzzer alerts can be used near sensors or in buildings to notify people immediately when pollution levels are high.

Threshold-Based Alerts: Alerts will be sent when AQI values exceed safe limits, informing users about the severity of the pollution levels and offering recommendations for action.

E. Local Monitoring Interface:

A local display unit, which could be an LCD or LED screen, will be installed in community centers or offices of local authorities. The real-time data on air quality will be displayed, with immediate feedback in the form of color-coded warnings (green is good, yellow is moderate, and red is hazardous) to make the information easily understandable for non-technical users.

Manual Data Retrieval: Using their mobile application, users in specific areas could use Bluetooth to retrieve their latest air quality data that has been captured from adjacent sensors manually without needing any type of internet connection.

Advantages:

A. Long-Range Communication:

LoRaWAN provides a longer range of communication than Wi-Fi, up to 15-20 km in rural areas, making it perfect for monitoring larger areas without constant infrastructure.

B. Low Power Consumption:

LoRaWAN is optimized for low-power devices, which allows air quality sensors to run on battery power for long periods, sometimes even months or years, without frequent recharging. This is particularly advantageous for remote locations where a reliable power source may not be available.

C. Affordable and Scalable:

Using Low-Cost Sensors and LoRaWAN, makes this system very low cost with regard to the deployment cost across geographically large regions such as villages, towns, and industrial zones.

D. Applicable to Rural Areas:

This system is quite useful for areas where internet access (Wi-Fi) is not available. It enables mass air quality monitoring across rural, mountainous, or remote areas where building traditional network infrastructure may be impossible.

E. Real Time Alerts Using GSM:

GSM-based SMS and auto-call alerts do not rely on internet connectivity and ensure that hazardous air quality conditions are reported quickly and reliably, even in rural or remote locations.

Limitations:

A. Bandwidth of Data:

LoRaWAN is a low-bandwidth network compared to Wi-Fi. Therefore, the system would be ideal for transmitting small packets of data, like air quality readings, and not large data files or video streaming.

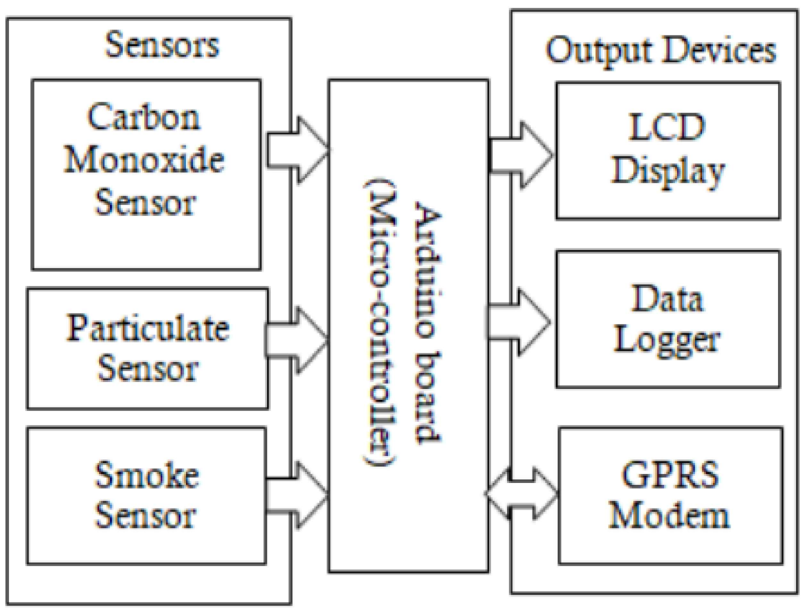
B. Dependency on GSM Network:

The effectiveness of SMS alerts will depend on the availability of a GSM network in the area. In areas without GSM coverage, alternative communication methods would need to be considered.

C. **Sensor Maintenance:**

Although the sensors are low-cost, they need regular calibration and maintenance to ensure long-term accuracy.

BLOCK DIAGRAM



The image gives a block diagram of an Air Quality Monitoring System. It describes the major components of the system and their interconnections:

A. **Sensors:**

Carbon Monoxide Sensor: Detects the concentration of carbon monoxide (CO) in the air.

Particulate Sensor: Measures the levels of particulate matter (e.g., PM2.5, PM10).

Smoke Sensor: Detects the presence of smoke particles in the air.

B. Microcontroller (Arduino Board):

The central processing unit of the system, which collects data from sensors, processes it, and controls the output devices.

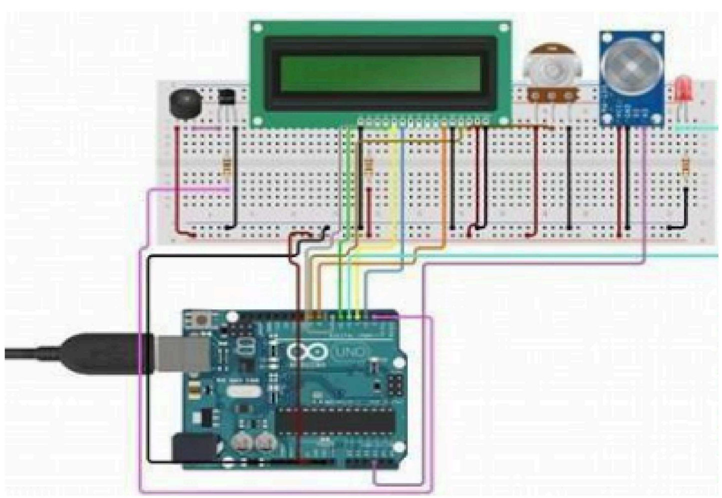
C. Output Devices:

LCD Display: This is what presents the air quality information in a friendly format to the user.

Data Logger: This stores the collected data to be analyzed later.

GPRS Modem: Data is transmitted to a server or other devices for real-time monitoring and alerts

Interfacing of Components:



HARDWARE AND SOFTWARE SPECIFICATION

HARDWARE

1. **SensorMQ135:** A gas sensor That detects air pollutants such as ammonia, benzene, and carbon dioxide, used for air quality monitoring.
2. **Arduino Uno:** A microcontroller board that processes sensor data and controls other components in the system.
3. **Buzzer:** An output device that emits audible alerts when pollutant levels exceeds safety thresholds.
4. **resistors:** A passive electronic component used to limit current flow and protect other components.
5. **Potentiometer:** A variable resistor used to adjust parameters like screen contrast or input sensitivity.
6. **Display Screen 16*2:** A liquid Crystal Display(LCD) that shows real-time air quality readings and alerts.

SOFTWARE

1. **Arduino IDE:**

   54 The Arduino IDE (Integrated Development Environment) is a software application used to write, compile, and upload code to Arduino boards. It supports C/C++ programming and provides a user-friendly interface for developing and debugging Arduino projects.

2. **Proteus:**

   In Proteus, 9 an air quality monitoring system can be simulated by adding various sensors (such as PM2.5 sensor, CO sensor) to the microcontroller, such as Arduino , reading environmental data. The simulation includes data processing and presenting values on an LCD or via alerts through simulated communication modules, such as GSM . Finally, Proteus makes it possible to simulate sensor readings in real-time, thereby testing the system's behavior and interaction before their physical implementation.

APPLICATIONS

A. Rural and Remote Area Monitoring

In many rural or remote areas, there is often no reliable access to either internet or Wi-Fi networks for traditional air quality monitoring. A real-time air quality monitoring system without Wi-Fi may be the solution by transferring data over long distances but does not require an Internet connection.

In rural agricultural areas where the quality of the air could be influenced by the burning of crops or even industrial activity, such systems will monitor PM2.5 and PM10, along with other gases such as CO and NO2. Local authorities as well as locals are warned by SMS messages or call notifications of threshold exceedances that may affect them in a safe or preventive measure to stay inside or mask their faces if they plan to venture outside.

This will ensure that all citizens in remote areas have an access to the critical information about air quality, therefore, improving their health and safety without requiring internet infrastructures.

B. Industrial and Manufacturing Plants

Industrial facilities and manufacturing plants usually emit a large quantity of air pollutants that pose risks to the workers and the people in the neighboring communities. A real-time air quality monitoring system, without Wi-Fi, installed in factories will be able to monitor CO, NO2, and VOCs in the environment.

Sensors placed in key areas within the plant can detect dangerous air quality levels and send real-time alerts (via GSM, SMS, or automated phone calls) to plant operators or safety officers, warning them of hazardous conditions. In case of a spike in pollutant levels, workers can be directed to evacuate or use protective gear.

This system improves workers' safety as it gives instantaneous information regarding environmental conditions, thus helping companies meet environmental standards and avoid fines while at the same time ensuring healthy workforces.

C. Urban Air Quality Monitoring

In big cities, due to traffic congestion, construction activities, and industrial operations, pollution levels are at an increased level, and these pollution levels may influence the health of the public. Real-time air quality monitoring systems, without Wi-Fi, can be used for the deployment of sensors across the city using LoRaWAN or GSM to monitor high-polluted but less internet-accessible areas such as slum areas, parks, or remote neighborhoods.

Sensors can measure the level of PM2.5, CO, and NO2 and send real-time reports to local authorities. Such authorities can automatically alert citizens via SMS or automated calls. Moreover, public displays show air quality readings in real-time, giving citizens that information needed to take precautionary measures (such as staying indoors or reducing the amount of physical activity).

This system ensures that residents in urban areas receive real-time air quality data, improving public health by giving them the information to avoid exposure during high pollution events.

D. Emergency Response and Disaster Management

It may be essential in the aftermath of natural disasters such as wildfires, volcanic eruptions, or industrial accidents. Here, air quality could rapidly deteriorate, endangering large populations. Such a real-time air quality monitoring system without Wi-Fi might become crucial where reliable Wi-Fi may be unavailable or disrupted.

Once the wildfire has burnt down, the air quality monitoring system will be able to monitor levels of pollutants such as smoke particulates (PM2.5) and carbon monoxide (CO). For hazardous air quality conditions, it can send out short message service alerts or autodialed phone calls for the local residents and response agencies. This can provide the evacuation of vulnerable individuals and timely interventions.

The system offers critical real-time data for emergency responders and the public during disaster events and helps reduce health risks, thus making emergency operations effective.

E. Public Health and Environmental Monitoring in Developing Countries

In many developing countries, the lack of robust air quality monitoring infrastructure, especially in rural and underdeveloped regions, poses a challenge to public health. A real-time air quality monitoring system without Wi-Fi can help address this gap by providing low-cost, scalable air quality monitoring.

Sensors can be deployed in both urban and rural areas to monitor common pollutants such as PM2.5, CO, and SO2. Data is transmitted through LoRaWAN or GSM to a central server or local authorities. The system sends SMS-based alerts to local health organizations and government agencies, informing them when pollution levels are dangerous. This enables local communities to take preventive measures and avoid exposure to harmful pollutants, especially during seasonal events like crop burning or industrial emissions.

The system provides valuable air quality data to public health authorities, who can then take timely action to protect vulnerable populations, improve air quality, and advocate for better environmental policies. This also empowers the general public with information to reduce exposure to air pollution, especially in low-resource settings.

F. Some key Benefits of These Applications

Improved Health and Safety: With immediate alerts, individuals are able to take appropriate actions towards their health.

Low-Cost: The low cost of sensors and the range communication methods used, LoRaWAN and GSM, make it inexpensive.

Scalability: It can easily be scaled to extend coverage to a much wider area without significant investments in heavy infrastructure.

Accessibility: It works in areas that lack internet or Wi-Fi, making it ideal for remote locations and developing regions.

CONCLUSION

Real-time air quality monitoring and alerting is essential to the ever-mounting challenges of air pollution; it is very critical especially for areas where conventional infrastructure and monitoring are lacking or are under a deficit. Increasing levels of urbanization, industrialization, and environmental degradation globally have made air quality of major concern for health, public, and environment generally. The proposed system provides an efficient, low-cost, and scalable solution to monitor and manage air pollution levels, particularly in areas where Wi-Fi and reliable internet infrastructure are unavailable.

The system has several benefits: it can provide real-time data on key air quality parameters such as PM2.5, PM10, CO, NO2, and SO2, not depending on Wi-Fi networks. The system ensures that air quality data can be transmitted over long distances with minimal power consumption, making it highly suitable for remote, rural, or industrial areas where Wi-Fi is not readily available, by leveraging LoRaWAN or GSM communication for data transmission. The system is able to send SMS-based alerts or automated phone calls, therefore allowing users to take proper precautions in a timely manner-avoid outdoor activities or protective gear when air quality is poor.

Low-cost sensors make this system affordable and accessible for communities, governments, or organizations, especially in developing countries where funding for conventional air quality monitoring systems could be limited. The system can easily scale up to cover larger areas such as entire cities, industrial zones, or remote regions and ensure broader monitoring coverage. This also helps in the provision of early warning by offering forecasted pollution levels that enables the authorities and the public to take preventive measures before reaching hazardous levels of pollution. The system has significantly reduced from a health perspective the dangers of poor air quality-children, the elderly and people with pre-existing respiratory ailments. Real-time alerts for users allow them to take appropriate remedial action to avoid hazardous pollutants, thus improving their public health outcomes. In addition to the above, continuous air quality monitoring can help make informed decisions by local authorities and environmental organizations on urban development plans, industrial regulations, and environmental policies.

In conclusion, the Real-Time Air Quality Monitoring and Alerting System without Wi-Fi is an innovative, practical, and cost-effective solution to the global issue of air pollution. It enhances public health safety by providing accurate, real-time air quality data, allowing individuals, communities, and governments to respond swiftly to deteriorating air quality conditions.

FUTURE SCOPE

The future scope for a Real-Time Air Quality Monitoring and Alerting System without Wi-Fi is vast, with numerous opportunities to enhance its functionality and reach. As communication technologies like 5G and NB-IoT become more accessible, they could replace current systems like GSM or LoRaWAN, offering faster and more reliable data transmission over longer distances. The system's accuracy and scope could also be improved with the development of advanced sensors that detect a wider range of pollutants, such as volatile organic compounds (VOCs) and ozone. Additionally, the integration of predictive analytics and machine learning could allow for better forecasting of air quality trends, enabling proactive measures to prevent health risks. The system could expand to include indoor air quality monitoring, ensuring that both indoor and outdoor environments are closely monitored.

Future development will make the sensor technologies more sensitive, tough, and cost-effective while monitoring air quality. There is potential for the coming generation of sensors to track a more diverse range of pollutants including VOCs, O3, and more greenhouse gases.

The system is expandable to monitor the indoor air quality, especially in an increasingly important task of overall air pollution control. Sensors could detect harmful pollutants such as formaldehyde, carbon dioxide (CO2), and particulate matter inside homes, schools, offices, and so on.

In the future, the system could include mobile applications or interactive platforms allowing users to receive personalized air quality notifications in their particular areas. These apps can provide advice based on personal health data, such as recommendations for asthma or heart conditions.

For example, Advanced Sensor Sensitivity, Public Participation and Awareness Tools, Extend the scope of the air quality monitoring up to Indoor Air Quality Monitoring.

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APPENDIX

SOURCE CODE

I have use Arduino IDE to program Arduino Uno board from https://utsource.net. So, first in the code we need to include the LiquidCrystal.h library header file.

```
#include LiquidCrystal.h    //Header file for LCD
```

Define the variables for different pins used in Arduino board for LCD, Buzzer, LED and MQ-135. Also, set threshold value as 250 ppm.

```
const int rs = 9, en = 8, d4 = 3, d5 = 4, d6 = 5, d7 = 6;    //pins of LCD connected to Arduino.
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);                  //lcd function from LiquidCrystal
int buz = 2;                //buzzer connected to pin 2
int led = 5;                //led connected to pin 5
const int aqsensor = A3;    //output of mq135 connected to A3 pin of Arduino
int threshold = 250;        //Threshold level for Air Quality
```

This will run one time and here we need to set Buzzer, LED as output device and MQ-135 as input device to Arduino Uno. Serial UART and LCD is also initialized.

```
void setup()

{
```

```
pinMode(buz, OUTPUT);      // buzzer is connected as Output from Arduino
pinMode(led, OUTPUT);      // led is connected as output from Arduino
pinMode(aqsensor, INPUT);  // MQ135 is connected as INPUT to Arduino
Serial.begin(9600);        // begin serial communication with baud rate of 9600
lcd.clear();               // clear lcd
lcd.begin(16, 2);          // consider 16,2 lcd
}
```

This will run infinite times and here we write our logic to read MQ-135 sensor data and display it on LCD screen and condition to turn ON and OFF LED and Buzzer.

```
void loop()

{
int ppm = analogRead(aqsensor);    // read MQ135 analog outputs at A0 and store it in ppm
Serial.print("Air Quality: ");     // print message in serail monitor
Serial.println(ppm);               // print value of ppm in serial monitor
lcd.setCursor(0, 0);               // set cursor of lcd to 1st row and 1st column
lcd.print("Air Qualit: ");         // print message on lcd
lcd.print(ppm);                    // print value of MQ135
if (ppm > threshold)               // check is ppm is greater than threshold or not

  {
  lcd.setCursor(1, 1);             // jump here if ppm is greater than threshold
  lcd.print("AQ Level HIGH");
  Serial.println("AQ Level HIGH");
  tone(led, 1000, 200);            // blink led with turn on time 1000mS, turn off time 200mS
  digitalWrite(buz, HIGH);         // Turn ON Buzzer
  }

else

  {
```

```
 digitalWrite(led, LOW);          // jump here if ppm is not greater than threshold and turn off LED
  digitalWrite(buz, LOW);          // Turn off Buzzer
  lcd.setCursor(1, 1);
  lcd.print("AQ Level Good");
  Serial.println("AQ Level Good");
  }

delay(500);
}
```

Circuit Design of Air Quality Monitoring and Alerting system using Proteus

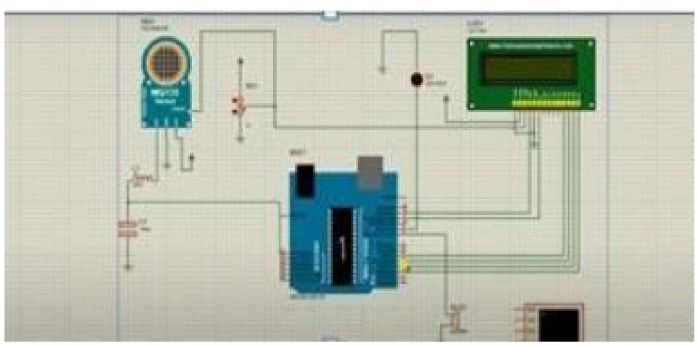

Figure 1 before execution

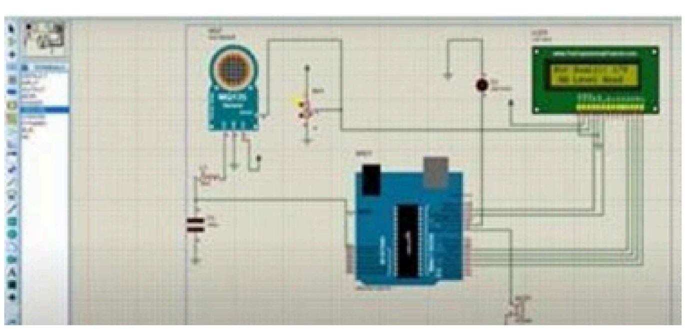

Figure 2 after execution