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Air Pollution Monitoring System Using IoT

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ABSTRACT:
This project investigates a novel air pollution monitoring system utilizing a networked sensor system and readily available low-cost microcontroller platforms. The system continuously monitors and analyzes air quality with the deployed air quality sensor, offering real-time data accessible through a remote server and mobile devices. This research not only demonstrates the system's functionality but also emphasizes the potential of affordable technologies for facilitating public understanding of air quality and empowering individuals to assess its impact on their surroundings.

KEYWORDS: — Internet of Things, Pollution, Air, Parts per Million.

I. INTRODUCTION

Air is a fundamental element for human survival, yet its quality is increasingly threatened by pollution. Air pollution occurs when harmful contaminants alter the atmosphere's natural composition, jeopardizing the health of humans, animals, and plants [1]. Measuring air pollutants in parts per million (ppm) or ug/m3 reveals the extent of this threat [2]. Pollutants, both primary (directly emitted) and secondary (formed from reactions), have severe consequences for public health, causing breathing difficulties, worsening respiratory conditions, and impairing visibility [3, 4]. Air pollution contributes to an alarming 7 million deaths annually and poses significant risks to children's respiratory health [5, 6]. In response to this crisis, researchers have developed various systems to monitor air quality. This paper focuses on the design and implementation of a smart air pollutant monitoring system using gas sensors, an Arduino microcontroller, and a Wi-Fi module. The primary objective is to create a system that effectively monitors, analyzes, and remotely logs air quality data, keeping information accessible and up-to-date.

II. OBJECTIVES

1. **Develop a cost-effective and efficient air pollution monitoring system:**
   Utilize readily available and affordable sensors to monitor key air pollutants.
   Design a compact and portable system for easy deployment in various environments.
2. **Real-time monitoring and data acquisition:**
   Continuously monitor air quality parameters like particulate matter (PM), carbon monoxide (CO), and nitrogen oxides (NOx).
   Develop a reliable data acquisition system to collect and store data at regular intervals.
3. **Data visualization and accessibility:**
   Implement a user-friendly platform for visualizing collected air quality data in real-time.
   Enable remote access to data through a web interface or mobile application for easy monitoring and analysis.

4. **System evaluation and validation:**

Evaluate the accuracy and reliability of the developed system compared to established air quality monitoring techniques.
Analyze the collected data to identify trends, patterns, and potential sources of air pollution.

5. **Promote environmental awareness and citizen science:**
Enhance public awareness about air quality issues through accessible data visualization.
Contribute to citizen science initiatives by sharing real-time air quality data with relevant stakeholders and communities.

These objectives aim to contribute to the development of practical and accessible air pollution monitoring solutions, promoting environmental awareness and citizen science efforts to combat this critical global challenge.

III. METHODOLOGY:

This section details the hardware components, system design, and operational principles of the proposed air pollution monitoring system.

Hardware Components:

- Arduino Uno microcontroller: The central processing unit of the system, responsible for controlling sensor data acquisition and communication.
- MQ-135 Gas Sensor: Detects the presence of various air pollutants and outputs an analog voltage proportional to the concentration (ppm).
- 16 x 2 LCD Screen: Provides a local interface for displaying real-time air quality readings.
- ESP8266 Wi-Fi Module: Enables wireless communication between the system and the internet for remote data transmission.
- Additional components: Breadboard, resistors, potentiometer, and connecting wires facilitate circuit construction and sensor integration.

System Design:

The system can be conceptualized into five layers (refer to Figure 1):

1. Environmental Parameters: The target pollutants measured by the system.
2. Sensor Characteristics: Understanding the functionalities and limitations of the chosen sensor (MQ-135).
3. Decision Making & Calibration: Establishing thresholds, data acquisition frequency, and sensor calibration procedures.
4. Sensor Data Acquisition: Utilizing the Arduino to collect sensor readings.
5. Ambient Intelligence Environment: Uploading data to a remote server for visualization and analysis.

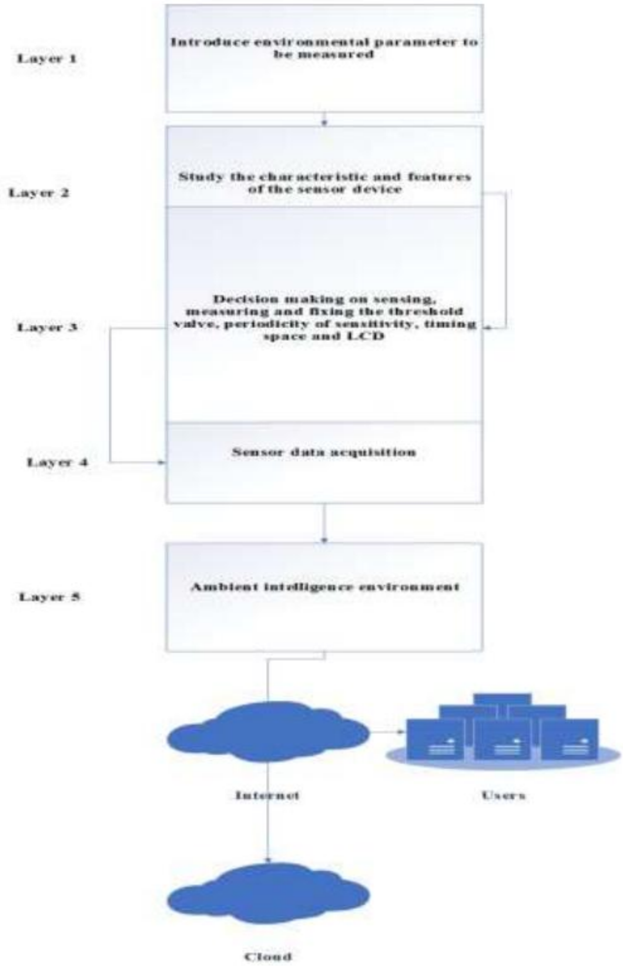

Fig. 1 Overview of the Proposed System

Fig. 2 Block Diagram of the Proposed Air Pollution Measuring System.

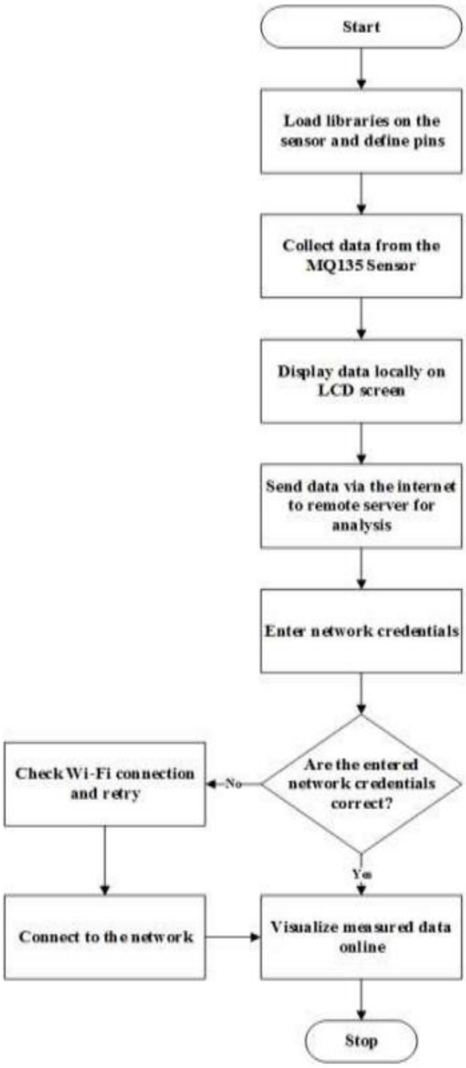

Fig. 3 Flow chart of the proposed system

Operational Principle (refer to Figure 3):

1. The Arduino initializes and sends a startup message to the LCD screen.
2. The MQ-135 sensor measures air quality and converts the concentration into a proportional voltage.
3. The calibrated sensor data is displayed on the LCD and transmitted to the Wi-Fi module.
4. The Wi-Fi module transmits the data to a designated server ("ThingSpeak") via the internet.
5. "Thing Speak" processes and visualizes the data as graphs or charts accessible through any internet-connected device.

IV. RESULTS AND DISCUSSION:

The online application used to analyze air quality data obtained from sensors in this proposed system was “Thing-speak”. Thing-speak is an open-source internet of Things application programming interface used to store and retrieve data from interconnected things using the hypertext protocol over the internet or via a local area network. It also provides access to a broad range of embedded devices and web services. This enables the creation of sensor logging applications that can be updated regularly. Figures 5-10 show the results of various pollutants that were obtained.

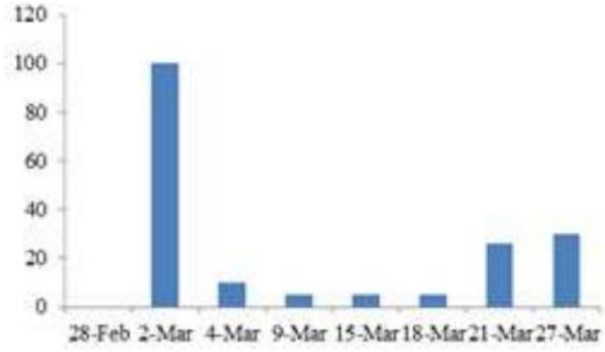

Fig. 4 Air Quality on Selected Days with an Aerosol as Sample Pollutant

Initially, minimal pollution is observed. Upon introducing the aerosol, air quality drops significantly from 0 to 100 ppm. Subsequent readings show a gradual decrease in aerosol concentration by March 27th.

Fig. 5 Air Quality on Selected Days with Dust as Sample Pollutant

Dust levels are lowest on February 28th but gradually increase over time. Fluctuations suggest the influence of external factors not considered in this study.

Fig. 6 Air Quality on Selected Days with a Gas as Sample Pollutant

Compared to other pollutants, the initial air quality appears significantly lower. A rapid drop in air quality is observed within a few days of measurement, highlighting the potential severity of gas pollutants.

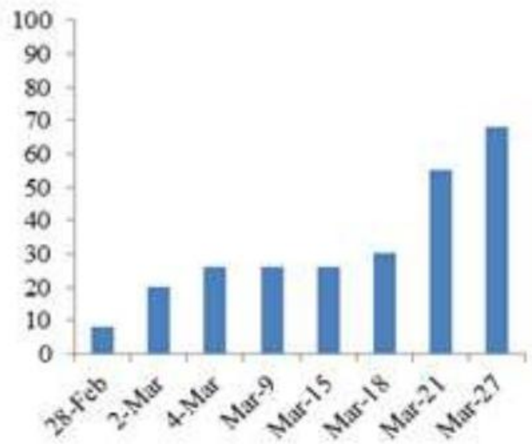

Fig. 7 Air Quality on Selected Days with Smoke as Sample Pollutant

Air quality associated with smoke shows a gradual decline, ranging from 8 ppm to 70 ppm depending on smoke concentration.

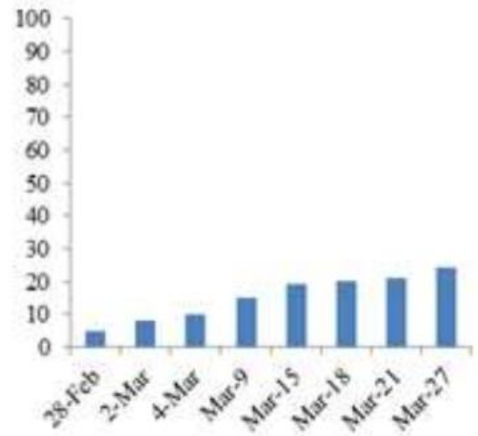

Fig. 8 Air Quality on Selected Days with Biogas as Sample Pollutant

The data was analyzed and published in the form of a scatter line graphs or bar charts on a channel. The channel corresponds to the air quality level as shown in Figure 10. The channel receives update every time from the remote sensor via the internet and represents the data received as a scatter line graph online.

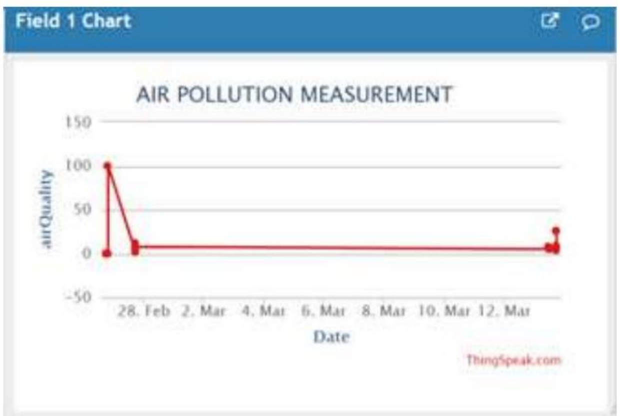

Fig 9 Air quality measurement as seen online

The visual representation of data on "thing-speak" corresponded with the measured air quality. The rate at which data displayed on "Thing-speak" changes was dependent on the network traffic and speed of the internet connection. The status of the air quality can be accessed at any time, with automatic updates occurring at defined time intervals.

V. CONCLUSION:

While this research successfully demonstrated a foundational air pollution monitoring system utilizing an LCD and the "Thing Speak" platform, it primarily focused on data collection and basic visualization. The true potential of this technology lies in its ability to:

Empower individuals: By expanding beyond single-unit displays and integrating with mobile applications, the system can deliver real-time air quality data and personalized recommendations directly to users, empowering them to make informed choices about their health and activities.

Inform decision-making: Integrating advanced data analysis techniques can unlock valuable insights into air quality trends, correlations with environmental factors, and even potential predictions. This information can be used by stakeholders like environmental organizations and policymakers to develop targeted interventions and effective mitigation strategies.

Foster collaboration: The system can be further developed into a network of interconnected sensors, providing a broader and more comprehensive understanding of air quality across diverse locations. This networked approach can facilitate collaboration and knowledge sharing among various stakeholders, ultimately contributing to collective efforts towards improving air quality for the benefit of all.

By fostering continuous development, collaboration, and exploration of these exciting possibilities, this research lays the groundwork for a future where smart air pollution monitoring systems play a crucial role in safeguarding public health and promoting a more sustainable and healthier future.

ACKNOWLEDGMENT:

The development of this air pollution monitoring system opens exciting avenues for further exploration and potential improvements. One key area lies in expanding sensor capabilities. This could involve integrating additional sensors to monitor a wider range of pollutants like volatile organic compounds (VOCs) and ozone (O3). Additionally, exploring advanced sensors with higher sensitivity and accuracy could further enhance data collection and provide even more detailed insights into air quality.

Optimizing the system for efficiency and effectiveness is another crucial area for future work. This might involve investigating strategies to reduce power consumption, allowing for longer operation and deployment in remote locations. Additionally, incorporating machine learning algorithms into the system could offer valuable capabilities, such as analyzing data to predict air quality trends and enabling proactive measures to be taken.

Furthermore, advanced data analysis and integration hold significant promise for the future. This could involve developing statistical models to identify correlations between air quality data and various environmental factors like weather patterns and industrial activity. Additionally, integrating the system with existing air quality monitoring networks could create a comprehensive and interconnected data infrastructure, providing a more holistic view of air quality across wider regions.

Enhancing communication and user engagement also presents valuable opportunities for future work. This could involve developing mobile applications with features like real-time air quality alerts and personalized health recommendations, empowering individuals to make informed decisions about their

health and well-being based on air quality conditions. Partnering with local communities and environmental organizations to utilize the collected air quality data for advocacy and policy interventions could further contribute to tackling air pollution challenges on a larger scale.

REFERENCES:

1. *Air Pollution Monitoring Focus: Arun Raj V., Priya R.M.P., and Meenakshi, V. (2017). Air Pollution Monitoring In Urban Area [Abstract or specific aspect relevant to your research]. International Journal of Electronics and Communication Engineering.*

2. *Smart Traffic System Design: Matthews, V. O., Uzairue, S. I., Noma-Osaghae, E., & Nwukor, F. (2018). Design and Simulation of a Smart Automated Traffic System in a Campus Community [Focus on relevant design aspects]. International Journal of Emerging Technologies and Innovative Research, 5(8), 492-497.*

3. *Air Quality Monitoring System Review: Priyanka, V. (2016). Review: Air Quality Monitoring System [Specific aspects reviewed relevant to your research]. International Journal of Advanced Research in Computer and Communication Engineering, 5(6).*

4. *Wireless Security System with Analytics: Matthews, V. O., Noma-Osaghae, E., & Uzairue, S. I. (2018). An Analytics Enabled Wireless Anti-Intruder Monitoring and Alarm System [Focus on analytics integration]. International Journal of Scientific Research in Science, Engineering and Technology, 4, 5-11.*

5. *Wearable Air Pollution Sensors: Nghi Dam, Andrew Ricketts, Benjamin Catlett, Justin Henriques (2017, IEEE). Wearable Sensors for Analyzing Personal Exposure to Air Pollution [Specific application of wearable sensors].*

6. *Al-Ali, A.R., Zualkernan, I., & Aloul, F. (2010). A mobile GPRS-sensors array for air pollution monitoring. IEEE Sensors Journal, 10(10), 1666-1671.*

7. *Snyder, E.G., Watkins, T.H., Solomon, P.A., Thoma, E.D., Williams, R.W., Hagler, G.S., Shelow, D., Hindin, D.A., Kilaru, V.J., & Preuss, P.W. (2013). The changing paradigm of air pollution monitoring.*

8. *Oscar Alvear, Nicola Roberto Zema, Enrico Natalizio, (2017). Using UAV-Based Systems to Monitor Air Pollution in Areas with Poor Accessibility. Journal of Advanced Transportation.*