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IOT Based Air Pollution Monitoring System

Anjali[1], Aruna[2], Bhavya[3], Prof. S K Aurad[4]
[1, 2, 3]*Student,* [4]*Associate Prof., Department of Electronics and Communication Engineering, PDA Engineering College, Kalaburagi, Karnataka, India*

Abstract: ***Air pollution has emerged as a major environmental hazard accelerated by metropolitan expansion, fossil fuel dependency, industrial emissions, and unsustainable urban practices. This research presents a real-time, IoT-centric air quality monitoring framework engineered to measure and interpret key atmospheric pollutants including CO_2, CO, NO_2, and airborne particulates. The solution integrates cost-effective multi-gas sensors, embedded processing units, and cloud-based services to capture, compute, store, and distribute pollution data securely through Wi-Fi connectivity. Core system features incorporate live visual analytics, threshold-driven notifications, historical pattern modeling, and decision-support insights for environmental stakeholders. Evaluation of the prototype demonstrates high scalability, portability, reduced power consumption, and resilience for long-duration deployment, positioning the system as a viable technology for smart infrastructure, environmental governance, and urban sustainability planning.***

I. INTRODUCTION

The progressive decline in atmospheric quality represents a global concern with profound implications for human health, climate stability, and biodiversity sustainability. Urban transport systems, thermal power stations, manufacturing industries, and waste incineration continuously introduce hazardous particulates and chemical pollutants into the air. Continuous exposure to such contaminants correlates with chronic respiratory illness, immune deficiencies, and ecosystem imbalance, necessitating proactive monitoring solutions. Conventional air quality assessment relies on centralized monitoring stations known for their precision but burdened by high capital cost, static operation, and limited geographical coverage. The emergence of Internet of Things (IoT) frameworks provides a transformative alternative by enabling distributed sensing, autonomous data exchange, and seamless public accessibility via cloud interfaces. By leveraging embedded controllers, wireless protocols, and predictive analytics, IoT systems empower real-time environmental diagnostics and facilitate a shift from reactive management to intelligent, preventive intervention strategies.

This research aims to harness IoT methodologies to enhance pollution surveillance, policy formulation, and citizen awareness, aligning with the technological foundations of smart city ecosystems and sustainable urban development.

II. LITERATURE REVIEW

1) Arduino- Based Real Time Air Quality and Pollution Monitoring System: This paper talks about Air pollution, from both human activities and natural sources, affects people's health worldwide. Pollutants like CO, CO_2, SO_2, NO_2, O_3, SPM, RSPM, and VOCs are concerning, especially in urban areas.

2) Air Quality Monitoring System: This paper talks about measuring air quality using MQ135 and MQ7 sensors. The project aims to increase awareness about pollution and help protect future generations. The Government of India has already banned some high-pollution motorcycles. Using IOT platforms like Blynk cloud, this system shows real-time air quality data for everyone to see, especially in places like New Delhi, which has very high pollution levels. The authors corrected mistakes in previous work and made it easy for everyone to track local air quality.

3) IOT-Based Real Time Air Pollution Monitoring System: This paper presents an IOT-based air pollution monitoring system in Coimbatore city. Air pollution affects people’s health, so countries set standards for safe pollutant levels. Traditional monitoring stations are expensive and complex to set up. The proposed system can measure air pollution in real time at any location, store the data in the cloud, analyze it, and display pollution levels in different zones like industrial, residential, and traffic areas.

4) Air Pollution Detection & Monitoring Using Internet of Things (IOT): This paper describes a low-cost IOT-based air pollution monitoring system using an ESP32 microcontroller. It measures air quality, temperature, and humidity, and sends data to the cloud via MQTT protocol. The system alerts workers about poor air quality in real time, making it very useful in industries with dangerous gases. It helps keep workers informed and safe by continuously monitoring the air.

5) IOT Enabled Air Pollution Monitoring and Awareness Creation System: This paper discusses a portable, low-cost IOT-based air pollution monitoring system designed to track air quality and raise public awareness. It monitors hazardous pollutants in real time using cloud services and displays AQI data through an Android app. Future updates include sending weekly or monthly air quality reports as notifications to users for easy access and awareness.

III. SYSTEM ARCHITECTURE

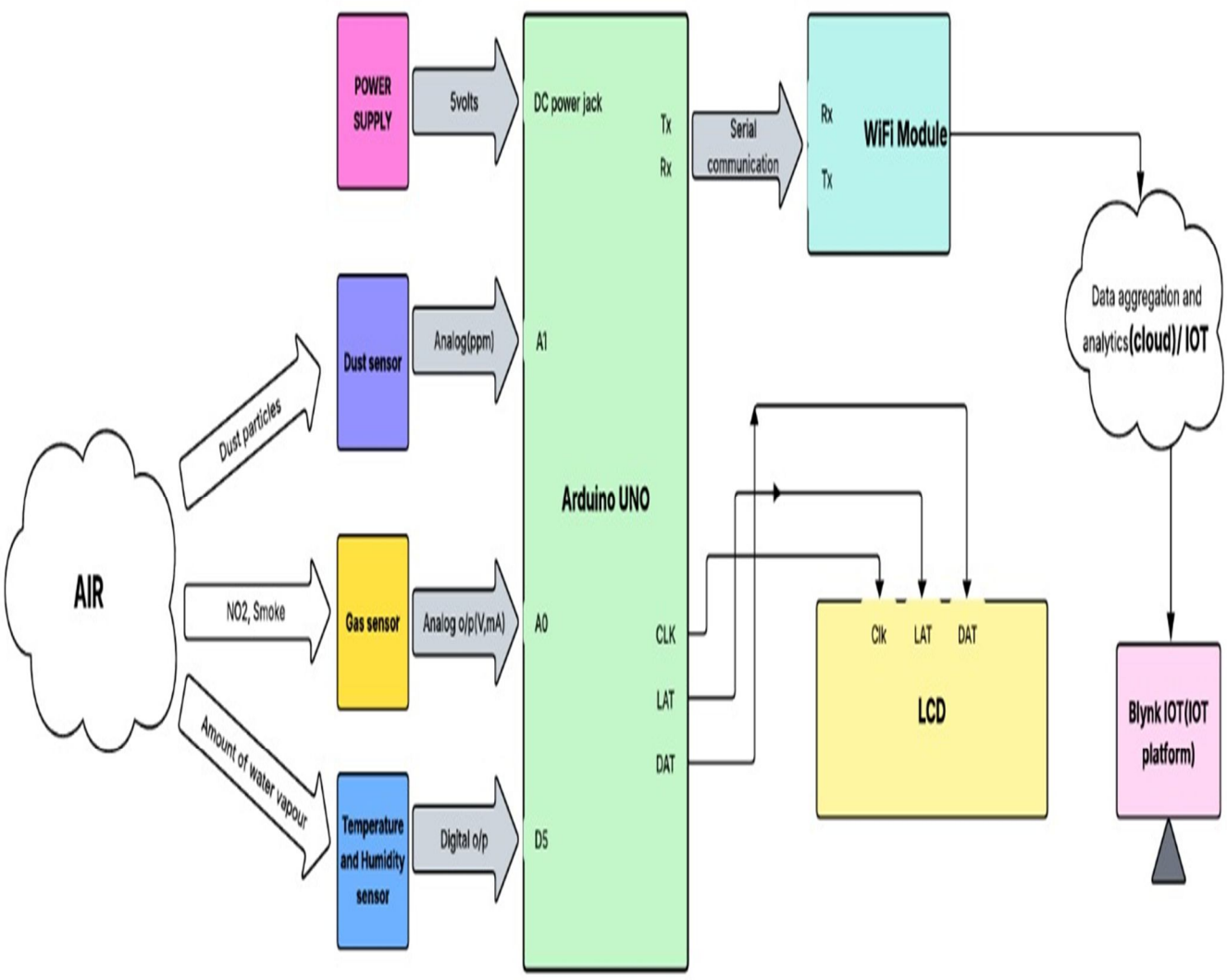

Fig.1. Detailed Block diagram of IOT based Air Pollution Monitoring System

The proposed architecture is composed of interconnected sensing modules, an embedded controller unit, a wireless transmission interface, and a cloud analytical platform. MQ135 and associated gas sensors quantify concentrations of CO_2, CO, NO_2, and volatile chemicals, while a particulate sensor computes dust density and pollution index. Temperature and humidity parameters, captured via DHT11/22, support atmospheric condition compensation to improve pollutant interpretation accuracy.

The microcontroller executes analog sampling, noise filtration, calibration compensation, digital encoding, and packet formation. Data packets are transferred to the IoT cloud dashboard through an ESP8266 Wi-Fi interface. The platform supports graphical analytics, multi-device access, downloadable reports, and automated alerts. Optional integrations include GPS-based mapping, solar charging modules, and mesh networking for deployment across large metropolitan areas.

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IV. METHODOLOGY

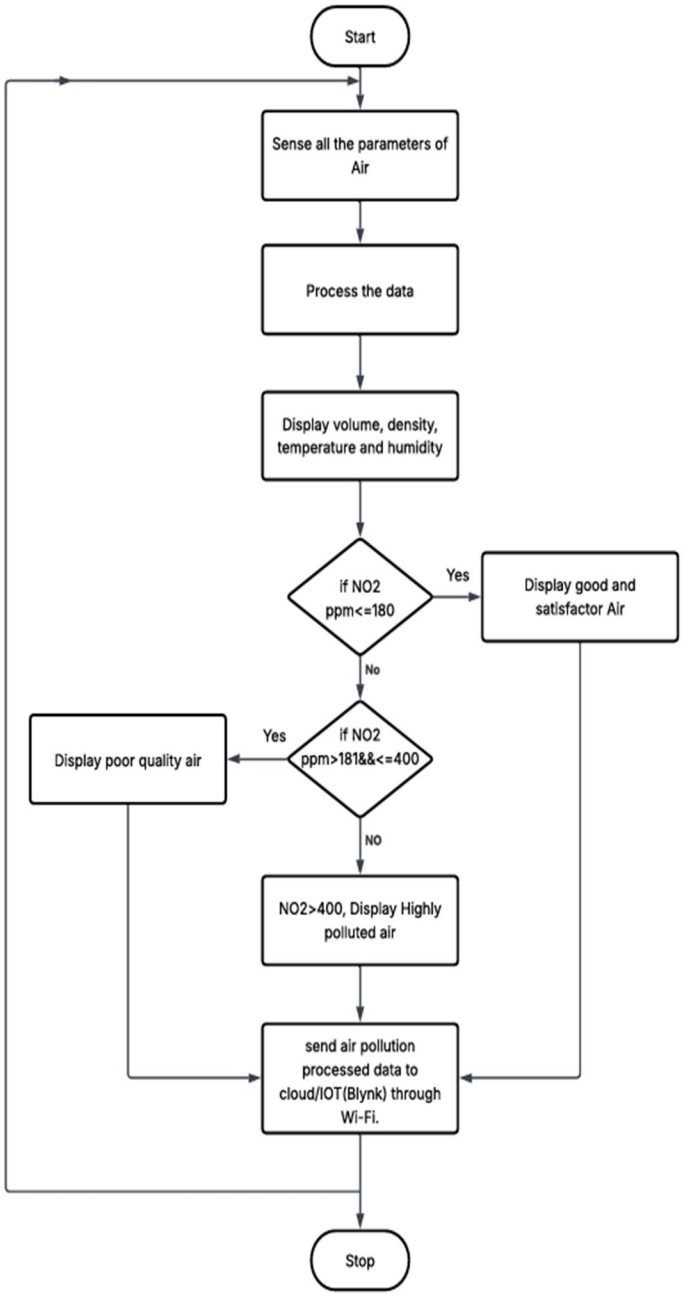

Fig.2. Flow Chart of IOT Based Air Pollution Monitoring System

The proposed IoT-enabled air quality monitoring solution functions by continuously capturing environmental indicators such as nitrogen dioxide concentration, particulate density, ambient temperature, and humidity through integrated sensing modules. Arduino processes the collected data, The acquired signals are digitized and evaluated against pre-established reference thresholds to classify the current air quality condition. Based on analytical comparison, the system labels the pollution status into qualitative levels such as optimal, moderate, or severely contaminated and activates relevant notifications when necessary. The validated output is subsequently forwarded to the Blynk cloud infrastructure through wireless communication, facilitating remote access, centralized data storage, and continuous monitoring. This cycle repeats continuously, ensuring real-time and reliable air quality tracking.

V. RESULT

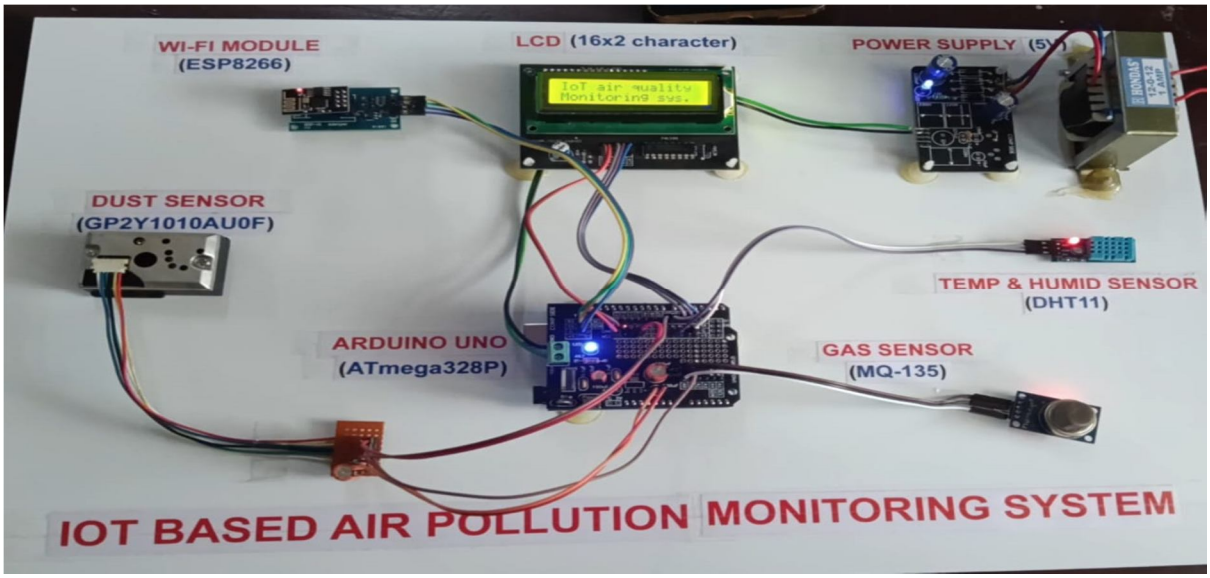

Fig.3. Hardware implementation of IOT based air pollution monitoring system

Fig.4. Displays showing Output of Temperature And Humidity, dust and gas sensors

The experimental prototype incorporates an Arduino-based control unit interfaced with gas, particulate matter, and temperature–humidity sensors to acquire multiple environmental parameters. An ESP8266 Wi-Fi module transmits data to the cloud, while a 16×2 LCD displays real-time values. Figure 4 illustrates the LCD outputs, showcasing temperature, humidity, dust concentration, and gas levels. The results demonstrate the system's ability to effectively monitor air quality in real time.

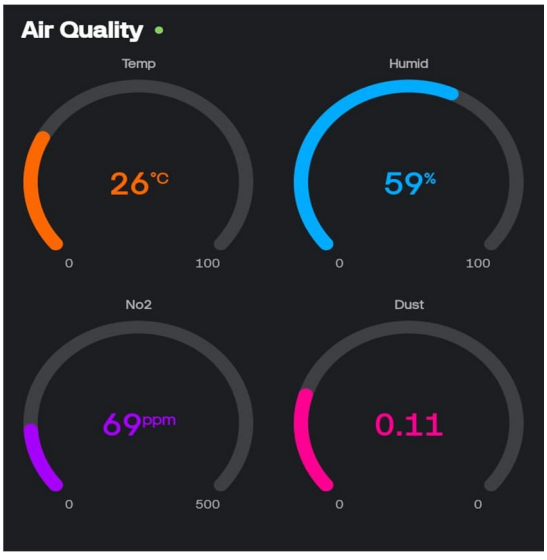

Fig.7. Blynk Application Output

VI. CONCLUSION

The developed IoT-integrated monitoring architecture delivers an economical and reliable approach for continuous assessment of surrounding air quality in real time. By combining sensors like MQ-135, dust sensors, and DHT11 with Arduino and ESP8266 Wi-Fi, it measures key parameters like gas concentration, particulate matter, temperature, and humidity. Data is displayed locally and uploaded to Blynk cloud for remote monitoring. Testing shows accurate readings, stable transmission, and reliable air quality classification, enabling timely pollution awareness and action. Suitable for various applications, future enhancements like solar power, mobile alerts, and ML-based prediction can boost its potential for large-scale environmental and public health monitoring.

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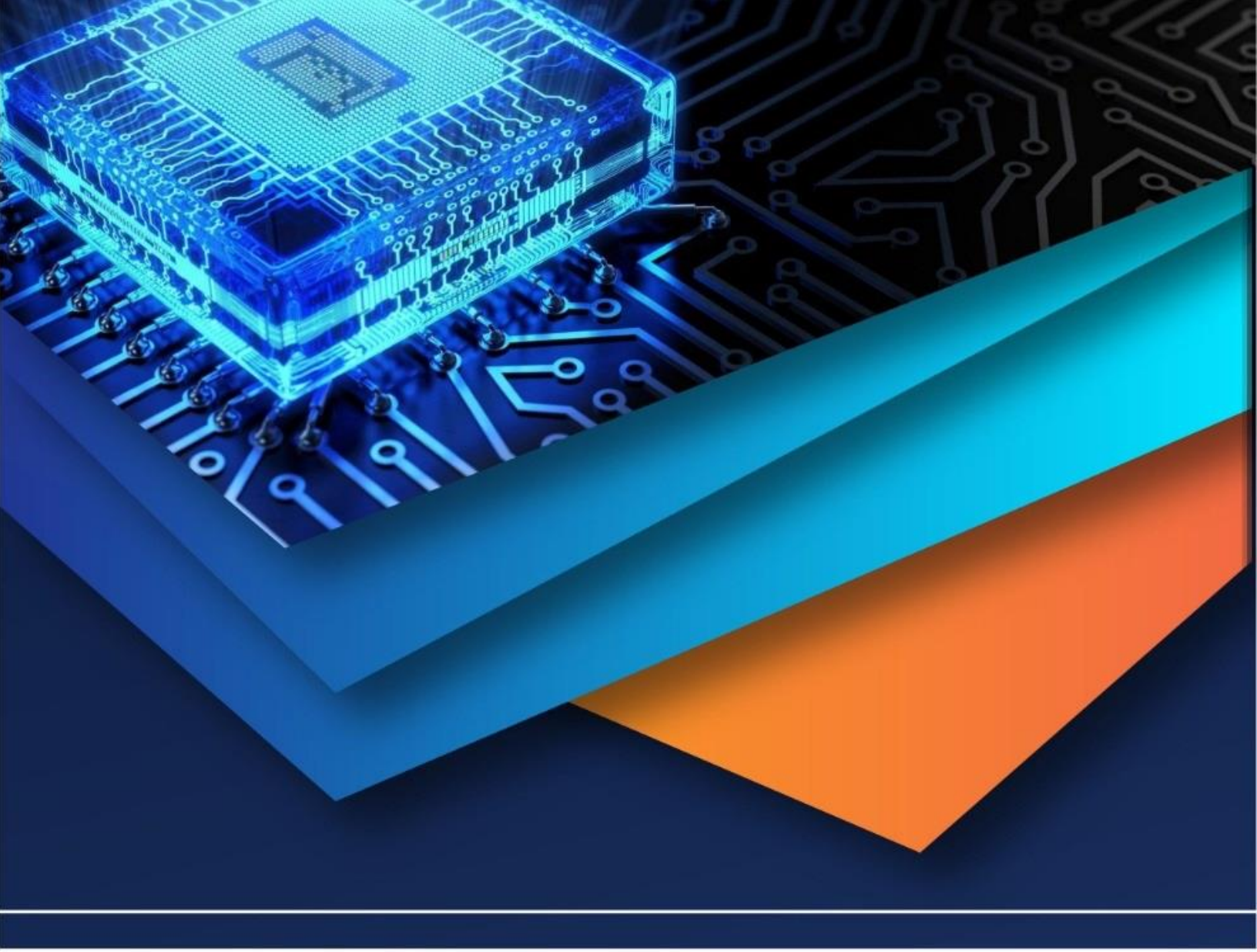

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