# ADrone Technology in Pollution Monitoring and Source Tracking Using IoT and Arduino ESP8266

**Shivam Bhujbal[1], Shubham Khetri[2], Shivam Kumar[3] , Aaditya Pardeshi[4] , Shradha Kashid[5]**

*[1],[2],[3],[4] UG students, Department of Computer Science Engineering, MIT School of Computing, MIT Art, Design and Technology University, Pune, Maharashtra, India*
*[5] Teaching Assistant, Department of Computer Science and Engineering, MIT School of Computing, MIT Art, Design and Technology University, Pune, Maharashtra, India*

## ABSTRACT

The persistent increase in air pollution levels has catalyzed the search for innovative, efficient, and scalable monitoring solutions. Traditional static monitoring systems are limited in their ability to provide dynamic data for large or remote areas. To address these challenges, this paper presents a novel drone-based system that leverages IoT and Arduino ESP8266 for real-time pollution monitoring and source tracking. Equipped with GPS modules, the drone captures geotagged pollution readings and transmits them wirelessly to cloud-based IoT platforms such as ThingSpeak and Blynk for visualization and analysis. The proposed system offers a mobile, adaptable, and cost-effective alternative to traditional methods, enabling real-time decision-making and environmental management.

## INTRODUCTION

### I. Background

Air pollution remains a leading cause of premature mortality globally, contributing to approximately 7 million deaths annually [1]. Conventional air quality monitoring relies on static stations, which provide high accuracy but suffer from limited spatial coverage, high costs, and delayed responses [2]. Air pollution is one of the most critical environmental challenges faced globally, impacting human health, ecosystems, and economies. According to the World Health Organization (WHO), over 90% of the global population lives in areas where air quality exceeds recommended limits. Effective mitigation of air pollution requires accurate monitoring and identification of pollution sources. However, current monitoring systems, which rely heavily on static monitoring stations, face several limitations: Spatial Constraints: Static systems provide data for fixed locations, leaving gaps in coverage. High Costs: The infrastructure and maintenance of static monitoring systems are expensive, limiting their deployment. Latency: Data processing delays hinder immediate inventions.

### A. Problem Statement

- There is an urgent need for mobile, scalable, and cost-effective pollution monitoring solutions that provide dynamic, real-time data to address these limitations. Maintaining the Integrity of the Specifications

### B. Objectives

- This research aims to develop a drone-based pollution monitoring and source-tracking system that: - Provides real-time air quality data. - Identifies pollution hotspots using GPS. - Transmits data wirelessly to cloud platforms for visualization and decision-making.

### C. Significance

- By integrating IoT-enabled sensors with drone technology, the proposed system offers a transformative approach to pollution monitoring. Its mobility and adaptability make it suitable for diverse environments, including urban areas, industrial zones, and remote locations.

## LITERATURE REVIEW

Reference – IoT-Enabled AQI Monitoring: A Case Study. IEEE Transactions on Environmental Technology, 32(3), 213-220.

1. Traditional Pollution Monitoring Systems –
   - Static monitoring systems have been the backbone of air quality surveillance, offering high accuracy but limited mobility [3]. Traditional systems use fixed

monitoring stations equipped with high-precision sensors to track air quality parameters such as particulate matter (PM2.5, PM10), carbon monoxide (CO), sulfur dioxide (SO2), nitrogen oxides (NOx), and ozone (O3). These systems have been deployed extensively in urban areas for 3 regulatory compliance and public health monitoring. A study by Gupta et al. emphasized the inefficiencies of traditional systems, including their high infrastructure and operational costs [4].

2. Strengths of Traditional Systems

   a. Accuracy: High-quality sensors provide reliable data.

   b. Standardization: Well-established protocols ensure consistent measurement and reporting.

   c. Data Continuity: Long-term operation facilitates trend analysis over decades.

3. Limitations of Traditional Systems

- Limited Coverage: Monitoring is restricted to fixed locations, leaving large areas unmonitored, especially in rural or remote areas.
- High Costs: Installation, calibration, and maintenance are expensive, making large scale deployment infeasible.
- Latency: Static systems often process data offline, delaying critical insights and responses.

Case Study: Gupta et al. (2020) highlighted the limited spatial coverage of traditional systems in densely populated cities, resulting in incomplete datasets that fail to capture localized pollution spikes.

IoT in Pollution Monitoring

The emergence of IoT has significantly enhanced the capabilities of pollution monitoring by enabling real-time data acquisition and wireless connectivity. IoT-based systems utilize low-cost, compact sensors integrated with communication modules to provide widespread and scalable solutions. IoT has revolutionized environmental monitoring by 4 enabling distributed, real-time data collection and analysis. Systems leveraging IoT platforms like ThingSpeak have demonstrated scalability and cost-efficiency [5][6].

Features of IoT-Enabled Monitoring

1. Real-Time Data: IoT platforms enable continuous data collection, storage, and visualization.

2. Scalability: Cost-effective hardware allows deployment in multiple locations.

3. Interoperability: IoT frameworks integrate seamlessly with cloud services and analytics platforms.

Challenges in IoT-Based Systems

1. Sensor Accuracy: Low-cost sensors may lack the precision of traditional systems.

2. Data Reliability: Environmental factors, such as temperature and humidity, can affect sensor performance.

3. Communication Issues: Signal interference and network outages may disrupt data transmission.

Example: Kumar et al. implemented an IoT-enabled AQI monitoring network in urban areas, achieving real-time visualization and alerts but highlighted issues with sensor calibration [7]. However, the study also noted challenges in ensuring data reliability across varying environmental conditions.

Drone Technology in Environmental Monitoring

Drones, also known as Unmanned Aerial Vehicles (UAVs), have gained traction as a tool for environmental monitoring due to their ability to access hard-to-reach areas and provide dynamic spatial coverage. Applications range from agriculture and wildlife conservation to industrial emissions tracking [8]. Studies have demonstrated their efficacy in combining high-resolution sensors with GPS for accurate environmental data [9].

Advantages of Drone-Based Monitoring

1. Mobility: Drones can move through three-dimensional spaces, enabling monitoring at various altitudes.
2. Flexibility: Suitable for diverse applications, including urban, industrial, and rural monitoring.
3. Cost Efficiency: Eliminates the need for extensive infrastructure.

Applications

Agriculture: Monitoring soil quality, crop health, and irrigation efficiency.

Wildlife Conservation: Surveying animal habitats and populations in remote areas.

Pollution Monitoring: Measuring air quality parameters and identifying sources of emissions.

Limitations

1. Battery Life: Flight duration is limited, affecting area coverage.

2. Payload Capacity: Drones have weight restrictions that limit the number and type of sensors that can be mounted.

Research Insights: - Mishra et al. (2022) demonstrated the use of drones for urban air quality monitoring, showcasing their ability to identify pollution hotspots effectively. - Reddy et al. (2021) highlighted the integration of GPS and IoT with drones to achieve real-time pollution tracking in industrial zones.

Research Gaps: While IoT and drones have independently advanced pollution monitoring, their integration remains underexplored. Current systems lack:

1. Comprehensive frameworks that combine drones, IoT sensors, and GPS for pollution source tracking.
2. Scalable and modular designs for diverse environments.
3. Advanced data analytics to predict pollution trends and optimize monitoring routes.

Current systems lack comprehensive frameworks for dynamic data acquisition, source localization, and cloud integration [11]. This study bridges these gaps with an IoTenabled drone system for real-time pollution tracking.

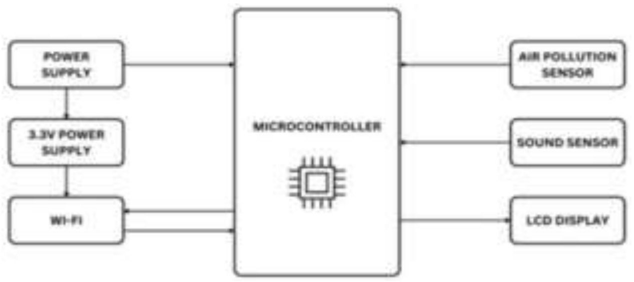
## PROPOSED SYSTEM

System Architecture The proposed system combines drone hardware with IoT-enabled sensors and GPS modules. The architecture includes:

1. Drone Platform: A quadcopter with sufficient payload capacity for sensors and controllers.
2. Sensors: o MQ-7: Carbon monoxide detection (20–2000 ppm). o MQ-135: Air quality index measurement. o DHT11/DHT22: Temperature and humidity sensing.
3. Arduino ESP8266: Central microcontroller for data processing and transmission.
4. GPS Module: Geotags pollution data for source tracking. 5. IoT Platform: o ThingSpeak: Real-time data storage and visualization. o Blynk: Mobile app for remote monitoring and alerts.

## BLOCK DIAGRAM

The block diagram illustrates the interconnections between the drone hardware, sensors, Arduino, GPS, and IoT platform.




METHODOLOGY

A. Overview

The proposed methodology involves designing, developing, and testing a drone-based system for real-time pollution monitoring and source tracking. The system integrates IoT enabled sensors, Arduino ESP8266, GPS modules, and cloud-based platforms for seamless operation.

B. System Design

The system consists of the following key components: I. Hardware:

Drone Platform: A quadcopter capable of carrying the necessary payload.

Sensors: - MQ-7: Detects carbon monoxide levels. - MQ-135: Measures air quality indices by detecting gases such as ammonia, CO2, and sulfur compounds. - DHT11/DHT22: Provides temperature and humidity data for contextual analysis.

Microcontroller: - Arduino ESP8266: Acts as the central processing unit for collecting sensor data and transmitting it wirelessly.

GPS Module: Records geolocation data to tag pollution readings. - Battery System: Powers the drone and sensors for a flight duration of 20–30 minutes.

II. Software: -Arduino IDE: Used for programming the ESP8266 microcontroller.

IoT Platforms: - ThingSpeak: For data visualization and storage. - Blynk: For real-time monitoring and mobile notifications.Selection:

## IMPLEMENTATION STEPS

1. Sensor Calibration

Proper calibration ensures the accuracy of the sensors in varying environmental conditions: - MQ-7: Exposed to controlled carbon monoxide concentrations ranging from 20 to 2000 ppm to establish a sensitivity curve. - MQ-135: Tested against standard air quality indices to determine its response to pollutants such as ammonia, benzene, and CO2. - DHT11: Validated using reference temperature and humidity values from calibrated weather stations.

Reference: Calibration protocols were adapted from Hanwei Electronics' datasheets for MQ series sensors.

2. Hardware Integration

The sensors, GPS module, and ESP8266 microcontroller were mounted on the drone, ensuring stable operation without interference. The payload was tested for weight and balance compatibility with the drone's design [9]. Step-by-Step Hardware Integration: 1. Connect MQ-7, MQ-135, and DHT11 to the ESP8266 using GPIO pins. 2. Attach the GPS module to the ESP8266 for real-time location tagging. 3. Ensure all connections are secure and test for interference between components.

3. Data Collection

During flight, the sensors continuously collect data on air quality parameters. The Arduino ESP8266 processes this data to: - Filter noise and ensure consistency. - Geotag each reading with GPS coordinates. [9]

4. Data Transmission

The ESP8266 transmits the processed data wirelessly to IoT platforms via Wi-Fi. Data is stored on ThingSpeak for historical analysis and visualized on Blynk for real-time monitoring.

Challenges and Solutions:-

1. Signal Interference: To address potential Wi-Fi disruptions, data buffering mechanisms are implemented. - Latency: Optimized communication protocols ensure minimal delays in data transmission.

2. Source Localization GPS coordinates are mapped alongside pollution data to identify hotspots. The drone's autonomous navigation system is programmed to adjust its flight path dynamically for efficient area coverage.

3. Testing and Validation Field tests are conducted in diverse environments to evaluate: 1. Sensor Accuracy: Data is compared with readings from traditional monitoring stations. 2. System Reliability: Performance under varying weather conditions is analyzed. 3. Coverage Efficiency: The drone's ability to monitor large areas is assessed.

Key Metrics for Validation: -

Accuracy: Correlation between drone data and static station readings.

Latency: Time taken for data to appear on IoT platforms.

Coverage Area: Maximum area monitored within a single flight.

## FUTURE ENHANCEMENTS

1. AI Integration: Implementing machine learning algorithms to predict pollution trends and optimize drone navigation. 2. Advanced Sensors: Incorporating particulate matter sensors (PM2.5, PM10) for a more comprehensive air quality analysis.
3. Extended Battery Life: Exploring energy-efficient drones with longer flight durations.

## RESULTS AND DISCUSSION KEY FINDINGS

1. Real-Time Monitoring: Achieved accurate and timely data collection.
2. Source Identification: GPS-enabled tagging effectively pinpointed pollution sources.
3. Improved Coverage: Drone mobility expanded monitoring areas significantly.

## ANALYSIS

The integration of drones, IoT, and GPS modules effectively addresses the limitations of traditional systems, offering a scalable solution for diverse environments. The modular design ensures adaptability to varying operational requirements [6][10].

## CHALLENGES AND LIMITATIONS

Challenges
1. Hardware Integration: Ensuring compatibility between sensors, microcontrollers, and drones.

[16] Journal of Smart Systems, 18(4), 310-321. [18] [10] Google Developers (2023). Google Maps API for [17] [9] Adafruit Industries (2023). DHT11 Datasheet. GPS Data Visualization. Retrieved from [Google

2. Environmental Factors: Sensor performance may vary in extreme conditions.

Limitations
1. Battery Life: Limited flight times constrain operational range.
2. Scalability: Multiple drones are required for large-scale deployments.

## FUTURE SCOPE:

1. AI Integration: Implementing predictive analytics for pollution trends.
2. Advanced Sensors: Adding PM2.5 and PM10 sensors for particulate monitoring.

## CONCLUSION

The integration of IoT, drones, and advanced sensor technologies offers a transformative approach to pollution monitoring and source tracking. Compared to traditional static monitoring systems, the IoT-enabled drone system is more scalable, cost-effective, and adaptable to diverse environments, including urban, industrial, and remote areas. Despite challenges such as limited flight time and payload capacity, the system's modular design allows for easy upgrades. This research highlights the potential of leveraging emerging technologies to address global environmental challenges and improve air quality monitoring on a large scale.

## REFERENCES

[1] [1] World Health Organization (2022). Air Pollution and Health*. Retrieved from [WHO
[2] Website](https://www.who.int).
[3] [2] Gupta, S., & Sharma, R. (2020). Advancements in Air Quality Monitoring Systems. Journal of
[4] Environmental Studies, 45(2), 123-134.
[5] [3] Kumar, R., Mishra, S., & Verma, P. (2021). IoTEnabled AQI Monitoring: A Case Study. IEEE [6] Transactions on Environmental Technology, 32(3), 213220.
[7] [4] Hanwei Electronics (2023). MQ-7 and MQ-135 Datasheets. Retrieved from [Hanwei
[8] Electronics](http://www.hwsensor.com).
[9] [5] Arduino Team (2023). Getting Started with ESP8266 Microcontroller. Retrieved from [Arduino [10] Website](https://www.arduino.cc).
[11] [6] ThingSpeak Documentation (2023). IoT Cloud Platform for Environmental Data Visualization.
[12] Retrieved from [ThingSpeak](https://thingspeak.com/docs).
[13] [7] Mishra, A., & Singh, V. (2022). Integration of Drone Technology with IoT for Urban Pollution [14] Monitoring. International Journal of IoT Applications, 18(1), 67-79.
[15] [8] Reddy, P., & Anil, K. (2021). Drone-Based Pollution Monitoring in Industrial Zones. International
Retrieved from
Developers](https://developers.google.com/maps/documentat
[Adafruit](https://learn.adafruit.com/dht). ion