IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 14, Issue 4, April 2025

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.807

9940 572 462 | 6381 907 438 | ijareeie@gmail.com | www.ijareeie.com

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |

Real-Time Vehicle Emission Detection with IOT and AWS

Dr. C. Infant Vinoth, Deepika S, Yocanantham K, Sumitha R U, Dhanush T, Sharmila. G

Assistant Professor, Department of Electrical and Electronics Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, India

Department of Electrical and Electronics Engineering, Sri Shakthi Institute of Engineering and Technology, Coimbatore, India

ABSTRACT: The increasing levels of air pollution caused by vehicular emissions have become a critical environmental concern, particularly in urban areas. Traditional methods of emission testing, which rely on periodic manual inspections, are often inefficient and lack real-time insights. This paper proposes an IoT-based real-time vehicle emission monitoring system utilizing AWS cloud services to address these limitations. IoT sensors integrated into vehicles continuously detect key pollutants such as carbon dioxide (CO_2), carbon monoxide (CO), and nitrogen oxides (NO_x). Data collected by microcontrollers (ESP32/Raspberry Pi) is transmitted to the cloud, where services such as AWS IoT Core, Lambda, and DynamoDB are used for real-time data processing, storage, and automated alerting. A cloud-based dashboard provides authorities with instant visibility into emission levels, enabling timely regulatory enforcement and identification of high-polluting vehicles. This system facilitates continuous monitoring, enhances policy-making through data-driven insights, and promotes sustainable urban mobility by encouraging proactive vehicle maintenance and environmental compliance.

KEYWORDS: Internet of Things (IoT), Vehicle Emission Monitoring, AWS Cloud Services, Real-Time Data Analysis, Air Pollution Control, ESP32, Environmental Compliance, Smart Transportation, Sustainable Urban Mobility, Emission Sensors, CO_2 Monitoring, CO Monitoring, NO_x Monitoring, Automated Alert System.

I. INTRODUCTION

Air pollution is a growing environmental and public health concern, particularly in rapidly urbanizing regions. A significant contributor to this issue is vehicular emissions, which release harmful pollutants such as carbon dioxide (CO_2), carbon monoxide (CO), and nitrogen oxides (NO_x) into the atmosphere. These pollutants not only degrade air quality but also contribute to global warming and respiratory illnesses. Despite stringent regulations and periodic inspection policies, traditional vehicle emission monitoring methods remain largely manual, infrequent, and reactive, making it difficult for authorities to track and control pollution in real-time.

With the advancement of the Internet of Things (IoT) and cloud computing, there is an opportunity to develop smarter, more responsive emission monitoring systems. IoT enables the integration of low-cost sensors with microcontrollers that can continuously monitor environmental parameters, while cloud platforms provide scalable infrastructure for data processing, storage, and visualization.

This paper proposes an IoT-based real-time vehicle emission monitoring system that leverages Amazon Web Services (AWS) to provide continuous, remote, and automated tracking of vehicular emissions.

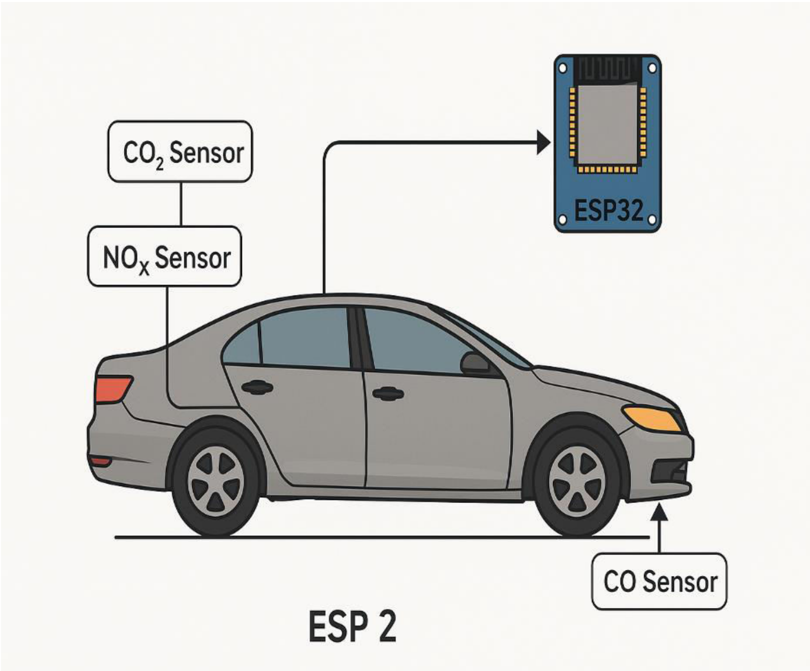
Sensors embedded in vehicles detect key pollutants and transmit the data through microcontrollers such as ESP32 or Raspberry Pi to the AWS cloud. AWS services including IoT Core, Lambda, and DynamoDB are utilized for secure device connectivity, serverless data processing, and efficient storage. Additionally, a real-time dashboard offers instant visibility into pollution levels, allowing regulatory bodies to identify and act upon violations promptly.

The proposed system aims to bridge the gap between existing emission control strategies and the need for dynamic, data-driven environmental monitoring. By automating the emission tracking process and enabling proactive intervention, this system contributes toward sustainable urban mobility, better air quality, and effective policy enforcement.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |



II. LITERATURE SURVEY

Vehicle emissions have become a significant concern in urban areas, contributing to air pollution and affecting public health. With the increasing urgency to mitigate environmental impacts, accurate and real-time monitoring systems are essential for managing vehicle emissions. Traditional methods, such as laboratory tests and periodic inspections, are inefficient in capturing real-time data. Consequently, recent advancements in Internet of Things (IoT) and cloud computing technologies have introduced innovative solutions for continuous and accurate monitoring of vehicle emissions. This section discusses the existing literature and key contributions in the field, highlighting real-time systems, sensor technologies, cloud integration, and the challenges faced.

A. Real-Time Vehicle Emission Monitoring Systems

Traditional emission testing often fails to provide timely insights into the dynamic nature of emissions from vehicles. Sharma et al. (2020) developed a Real-Time Vehicle Emission Monitoring and Visualization System (RTVEMVS) to address this gap. The system integrates real-time data collection, by combining data from multiple sources such as vehicle types, traffic flow, weather conditions, and vehicle speed, RTVEMVS enables authorities to identify pollution hotspots and high-emission vehicles. The system uses WebGIS technology and AREMOD dispersion models for precise emission estimation, which aids urban authorities in making informed, real-time decisions.

B. On-Board Emission Measurement Systems

On-board emission measurement systems have emerged as effective tools for collecting emission data under real-world driving conditions. Yang et al. (2018) introduced an on-board system that combines a gas analyzer and GPS unit to capture emissions and driving patterns. This approach provides more representative data compared to traditional testing methods, which are often conducted in controlled environments. By monitoring emissions in various driving conditions, on-board systems enable more accurate modal emission modeling, which predicts pollutant levels based on specific driving behavior and traffic flow.

C. Wireless Sensor Networks for Emission Data Transmission

The ability to continuously monitor emissions across large vehicle fleets is a major benefit of wireless sensor networks (WSNs). Kumar et al. (2019) explored the use of NOx exhaust gas sensors integrated into WSNs to monitor emissions in real time. This system enables the wireless transmission of data, which can be analyzed remotely, allowing for immediate alerts when emissions exceed regulatory thresholds. This wireless architecture ensures scalability and flexibility, making it possible to monitor a large number of vehicles continuously without requiring physical

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |

infrastructure. The system also supports real-time feedback mechanisms to reduce emissions by alerting drivers of excessive pollution levels.

D. Sensor Technologies for Pollutant Detection

The core of any emission monitoring system lies in the quality and accuracy of the sensors used to detect pollutants such as CO, CO_2, and NO_x. Reddy et al. (2020) emphasized the role of semiconductor gas sensors in detecting pollutants in vehicle exhaust. These sensors provide a cost-effective and efficient way to monitor emissions in real time. In addition to detecting pollutants, these sensors can trigger corrective actions such as activating emission-reduction technologies or notifying drivers when pollutant levels exceed acceptable limits. The continuous improvement in sensor accuracy is a key factor driving the development of reliable and real-time emission control systems.

E. Integration of GPS and GSM for Location-Based Emission Monitoring

The integration of GPS and GSM technologies with emission sensors allows for location-based monitoring, which is essential for understanding the spatial distribution of pollution. Singh et al. (2021) presented a system that uses GPS for vehicle location tracking and GSM for real-time data transmission. This system enables authorities to track high-emission vehicles in specific geographical areas, making it possible to enforce regulations and identify pollution hotspots. This location-based approach also supports the development of targeted intervention strategies, such as directing vehicles with excessive emissions to low-pollution routes or locations.

F. Challenges in Real-Time Emission Monitoring

While significant progress has been made in real-time emission monitoring, several challenges remain. One of the primary issues is the accuracy of sensors under real-world conditions, where external factors such as weather, vehicle load, and traffic conditions can influence sensor readings. Sensor calibration is also crucial to ensure the reliability of the collected data. Additionally, integrating heterogeneous data sources, such as traffic data, weather conditions, and vehicle-specific information, remains complex. This data must be harmonized and analyzed effectively to provide meaningful insights. Finally, the scalability of these systems remains a significant challenge, especially when monitoring large numbers of vehicles or an entire urban road network.

G. The Role of Cloud Computing in Emission Monitoring

Cloud computing platforms like Amazon Web Services (AWS) are transforming the way emission data is stored, processed, and analyzed. By offering scalable storage and computing power, cloud platforms enable the management of large volumes of data collected from multiple vehicles in real time. Cloud integration supports data analytics and machine learning models to detect anomalies, predict future emissions, and provide actionable insights. Real-time dashboards and alerts enable authorities to take immediate action when pollutant levels exceed acceptable thresholds. Cloud platforms also enable remote monitoring, allowing environmental agencies to manage emission data without the need for extensive on-site infrastructure.

III. SYSTEM ARCHITECTURE

The Real-Time Vehicle Emission Detection System is designed to leverage Internet of Things (IoT) sensors and AWS Cloud Services to enable continuous, real-time monitoring of vehicle emissions. The system is composed of four primary layers: Sensor Layer, Data Collection and Communication Layer, Cloud Processing Layer, and User Interface Layer. This architecture ensures effective monitoring, data processing, and reporting of vehicle emission data to regulatory authorities, fleet operators, and drivers.

A. Sensor Layer (Data Collection)

The first layer involves collecting data from various sensors installed in the vehicle's exhaust system and onboard diagnostics. The sensors measure pollutants such as CO_2, CO, NO_x, and PM2.5, which are the main contributors to air pollution from vehicles. The sensors are directly integrated with the vehicle's exhaust system to ensure accurate emissions data.

1. **IoT Sensors:**

a. **CO_2 Sensors:** Measures carbon dioxide emissions.
b. **CO Sensors:** Monitors carbon monoxide levels.
c. **NO_x Sensors**: Detects nitrogen oxides.
d. **PM2.5 Sensors:** Monitors particulate matter.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |

2. Vehicle OBD-II (On-Board Diagnostics):

An optional layer for collecting additional data such as fuel consumption, engine parameters, and vehicle-specific erformance metrics. This data can be combined with the sensor data for a more comprehensive analysis.

3. Microcontroller (ESP32/Raspberry Pi):

These microcontrollers interface with the sensors and manage the data collection. They act as the gateway between the sensors and the cloud, converting sensor data into digital signals and transmitting it to the cloud. These microcontrollers can also handle basic data processing, such as filtering or preprocessing before transmission.

B. Data Collection and Communication Layer

Once the data is collected from the sensors, it is transmitted securely to the cloud for further processing. This layer ensures the seamless and reliable communication between the vehicle's onboard system and the AWS cloud infrastructure.

1. Wireless Communication Protocols:

- **Wi-Fi**: For transmitting data when the vehicle is within range of a Wi-Fi network.
- **LoRaWAN:** For long-range, low-power communication where Wi-Fi is not available, such as in rural or remote areas.

2. AWS IoT Core: This service securely receives the data from the microcontroller via a wireless communication protocol. It ensures that data is securely transmitted from the vehicle to the cloud, leveraging standard protocols like MQTT or HTTP.

3. Real-Time Data Transmission: The data is transmitted in real time, allowing the cloud platform to receive continuous data from the vehicles without delay.

C. Cloud Processing Layer

This layer is responsible for processing and analyzing the data received from the vehicles. The AWS Cloud provides a range of services to handle the vast amounts of data generated from the sensors, process this data in real-time, and generate insights or alerts based on predefined thresholds.

1. **AWS Lambda:** The serverless AWS Lambda function is triggered when new data is received from AWS IoT Core. It processes the data, performs computations such as:
   - **Emission Calculation:** It calculates the concentration of CO_2, CO, NO_x, and PM2.5.
   - **Threshold Check**: Compares the emission data with regulatory thresholds to identify vehicles that exceed permissible pollution levels.
2. **AWS DynamoDB**: The processed emission data is stored in AWS DynamoDB, a NoSQL database. DynamoDB ensures efficient data storage and retrieval, with low latency, allowing for quick access
3. **Data Analytics:** Amazon QuickSight or Amazon SageMaker (optional) can be used to analyze data patterns over time, identify pollution trends, and create machine learning models that predict future emissions based on various parameters like driving behavior and traffic conditions.
4. **Automated Alerts:** If the emission data exceeds the predefined threshold, AWS SNS (Simple Notification Service) or AWS SES (Simple Email Service) can be used to send real-time alerts to relevant authorities, fleet managers, or vehicle owners.

D. User Interface Layer

This layer enables the stakeholders to access real-time information and reports related to vehicle emissions. It provides tools for authorities, fleet managers, and drivers to monitor emission levels and take appropriate actions.

1. **Web Dashboard**: A web-based dashboard provides real-time visualization of emission data. This dashboard shows information such as:
   - **Current Emission Levels:** Real-time CO_2, CO, NO_x, and PM2.5 concentrations.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |

- **Vehicle Location:** Using GPS data integrated into the emission data for location-based monitoring.
- **Emission History:** Historical data trends for individual vehicles or fleets, enabling the tracking of emissions over time.

2. **Mobile Application:** A mobile application for fleet managers and vehicle owners can be used to monitor emissions on the go. The app provides real-time alerts, historical data, and notifications when a vehicle's emissions exceed acceptable levels.
3. **Automated Alerts and Notifications:**
   - **Email/SMS Alerts**: Stakeholders such as authorities or fleet managers receive notifications when a vehicle exceeds emission thresholds.
   - **In-App Notifications:** Real-time alerts within the mobile or web application to notify users of high emissions or maintenance needs.

E. System Workflow

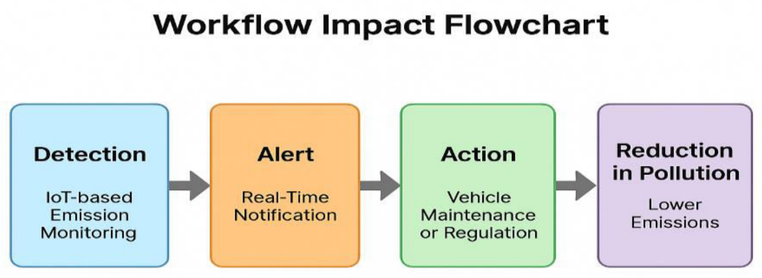
The workflow of the system can be summarized as follows:

1. **Data Collection:** IoT sensors in the vehicle's exhaust system collect data on pollutants like CO_2, CO, NO_x, and PM2.5.
2. **Data Transmission:** The microcontroller (ESP32/Raspberry Pi) transmits this data wirelessly via a protocol (Wi-Fi or LoRaWAN) to AWS IoT Core.
3. **Data Processing:** AWS Lambda processes the data, calculates emission levels, and checks if they exceed the permissible thresholds.
4. **Data Storage:** The processed data is stored in AWS DynamoDB and optionally archived in AWS S3.
5. **Real-Time Alerts:** When emissions exceed thresholds, automated alerts are sent via AWS SNS or AWS SES to the relevant stakeholders.
6. **User Access:** Authorities, fleet managers, and drivers access real-time data via the web dashboard or mobile application, enabling them to take corrective actions.

F. Cloud Infrastructure and Security

Security is a priority in the design of the system. The cloud infrastructure is protected by AWS security services, such as:

- **AWS Identity and Access Management (IAM):** Ensures only authorized users can access data or manage the system.
- **Data Encryption:** All data is encrypted during transmission (using TLS/SSL) and while stored (using AES-256 encryption).
- **AWS CloudWatch:** Provides monitoring of the system's health, ensuring uptime and performance.
- **AWS Key Management Service (KMS):** Manages encryption keys with centralized control, logging, and automatic key rotation to strengthen data protection.
- **AWS Shield and AWS WAF (Web Application Firewall):** Defend against Distributed Denial of Service (DDoS) attacks and filter malicious traffic, improving application resilience.



| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |

IV. IMPLEMENTATION OF PROPOSED SYSTEM

A. Hardware Implementation

1. IoT Sensors for Emission Detection

- Sensor Selection: Various gas sensors are used to detect pollutants from the vehicle exhaust, such as CO_2, CO, NO_x, and PM2.5. These sensors are carefully selected for their sensitivity, accuracy, and durability in automotive environments.
  - **CO_2 Sensor:** Measures carbon dioxide concentrations in the exhaust gases.
  - **CO Sensor**: Monitors carbon monoxide levels.
  - **NO_x Sensor:** Detects nitrogen oxides, which contribute significantly to urban air pollution.
  - **PM2.5 Sensor:** Measures particulate matter in the air, which is crucial for understanding fine particulate pollution.
  - Sensor Integration: The sensors are integrated into the vehicle's exhaust system in such a way that they can continuously measure pollutant concentrations during vehicle operation. The data is collected through the sensor interfaces and sent to the microcontroller processing.

2. Microcontroller (ESP32/Raspberry Pi)

- ESP32 or Raspberry Pi microcontrollers are used to interface with the sensors and process the collected data. These devices are equipped with Wi-Fi or LoRaWAN communication capabilities, enabling the data to be transmitted to the cloud.
- The microcontroller performs initial data processing, such as filtering out noise and performing basic calculations (e.g., averaging sensor readings) to prepare the data for transmission to the cloud.

B. Software Implementation

1. Data Collection and Transmission to Cloud

- **Communication Protocols**: The data collected from the sensors is transmitted using wireless communication protocols such as Wi-Fi or LoRaWAN. Wi-Fi is used in urban areas where coverage is available, while LoRaWAN is employed in more remote or rural locations where long-range communication is necessary.
- **AWS IoT Core:** The microcontroller sends the data to AWS IoT Core, which securely handles device connections, manages data transmission, and routes the data to the cloud for further processing. The data transmission follows the MQTT (Message Queuing Telemetry Transport) protocol, which is lightweight and efficient for IoT applications.

2. Cloud Data Processing

- **AWS Lambda Functions:** Once the data is received by AWS IoT Core, it triggers an AWS Lambda function, which processes the data. The Lambda function performs several key tasks:
- **Data Validation:** Ensures that the data is within expected ranges and is not corrupted.
- **Emission Calculations:** The Lambda function calculates the concentration of various pollutants (CO_2, CO, NO_x, PM2.5) based on the raw sensor readings.
- **Threshold Checking:** The function compares the calculated values against predefined emission thresholds. If any pollutant level exceeds the regulatory limit, an alert is triggered for immediate action.
- **Data Storage:** The processed data is stored in AWS DynamoDB, a fast and flexible NoSQL database, which ensures high availability and low-latency access to data. Historical emission data is stored, allowing stakeholders to access past readings and track vehicle emissions over time.
- **Data Backup:** The historical data and logs can also be archived in AWS S3 for long-term storage and analysis.

3. Data Analytics and Visualization

- **Amazon QuickSight**: The collected data is processed and visualized using Amazon QuickSight, a business intelligence service that allows stakeholders to create interactive dashboards and gain insights into vehicle emission trends. This tool provides real-time insights into emission levels, vehicle performance, and compliance with emission standards.
- **Historical Data Analysis:** Long-term emission data can be analyzed to identify trends, patterns, and correlations between vehicle type, fuel consumption, and emission levels. This helps in decision-making and policy formulation for emission reduction strategies.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |

C. User Interface Layer

1. Real-Time Dashboard

A web-based dashboard is developed using AWS Amplify or AWS QuickSight to provide a user-friendly interface for authorities, fleet managers, or drivers. The dashboard displays:

- **Real-Time Emission Levels:** Current pollutant levels for each vehicle.
- **Vehicle Location:** Integrated with GPS data to map the vehicles and monitor their real-time locations.
- **Alerts and Notifications**: When a vehicle's emissions exceed the permissible threshold, an alert is displayed on the dashboard in real-time.
- **Historical Trends**: Provides insights into past emission data, allowing for analysis of the vehicle's environmental impact over time.

2. Mobile Application

A mobile application can also be developed to provide a more flexible and portable monitoring solution. The app will allow fleet managers, drivers, and environmental authorities to access real-time emission data and receive notifications when emission levels exceed the limits. It will also allow users to check the vehicle's emission history and take necessary actions to maintain compliance.

3. Automated Alerts and Notifications

The system sends automated alerts using AWS SNS (Simple Notification Service) or AWS SES (Simple Email Service). Alerts are sent to fleet managers, vehicle owners, and relevant authorities when emissions exceed the set thresholds. Notifications can be sent via SMS, email, or directly through the mobile or web application.

D. System Integration and Testing

1. System Integration

- The hardware components (sensors, microcontroller) and software components (AWS cloud services, web/mobile dashboard) are integrated to form a unified system. All data flows seamlessly from the vehicle sensors to the cloud for processing, storage, and real-time monitoring.
- **Testing and Calibration:** Each sensor is calibrated to ensure accurate pollutant readings. The communication between the microcontroller and AWS services is tested for reliability and data integrity.

2. Field Testing

The system is tested on a fleet of vehicles in real-world scenarios. Data is collected and transmitted in real-time to ensure that the system can accurately detect and report emissions. The testing phase ensures that the system is capable of handling a large number of vehicles and providing accurate, real-time data to users.

E. Security and Data Privacy

1. Data Encryption and Security

Data transmitted between the vehicle sensors and the cloud is encrypted using TLS/SSL to prevent unauthorized access. Additionally, data stored in AWS DynamoDB and AWS S3 is encrypted using AES-256 encryption to ensure data confidentiality.

2. Access Control

The system uses AWS Identity and Access Management (IAM) to manage user access. Only authorized personnel, such as fleet managers or environmental regulators, have access to sensitive emission data.

.

V. WORKING

The **Real-Time Vehicle Emission Detection System** works by continuously monitoring vehicle emissions using IoT sensors, which measure pollutants such as **CO_2**, **CO**, **NO_x**, and **PM2.5** from the vehicle's exhaust.

These sensors send the collected data to a microcontroller (like **ESP32**), which processes and transmits the data to the cloud via **Wi-Fi** or **LoRaWAN**.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

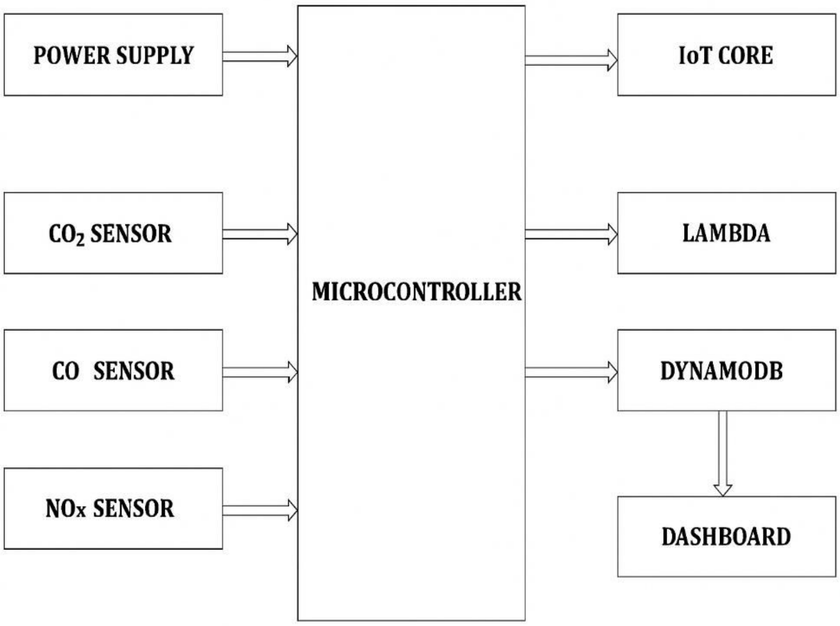
| DOI:10.15662/IJAREEIE.2025.1404038 |

Once the data reaches **AWS IoT Core**, it is routed securely to **AWS Lambda**, where pollutant concentrations are calculated and compared against predefined emission thresholds.

If any pollutants exceed the permissible limits, the system triggers alerts using **AWS SNS** or **AWS SES**. The emission data is stored in **AWS DynamoDB** for future access and analysis. Real-time emission data is displayed on a **web-based dashboard** and can also be accessed through a **mobile app or as a sms message**, enabling users to track the emission levels and locations of their vehicles.

Automated alerts are sent to fleet managers, vehicle owners, or regulatory authorities when pollution exceeds thresholds, providing timely notifications with vehicle details, location, and the specific pollutant level.

The system operates seamlessly to ensure compliance with emission standards, utilizing secure data transmission through **TLS/SSL encryption** and managed access through **AWS IAM**. By providing real-time insights and alerts, the system helps improve air quality and regulatory enforcement in urban areas.



VI. RESULT AND DISCUSSION

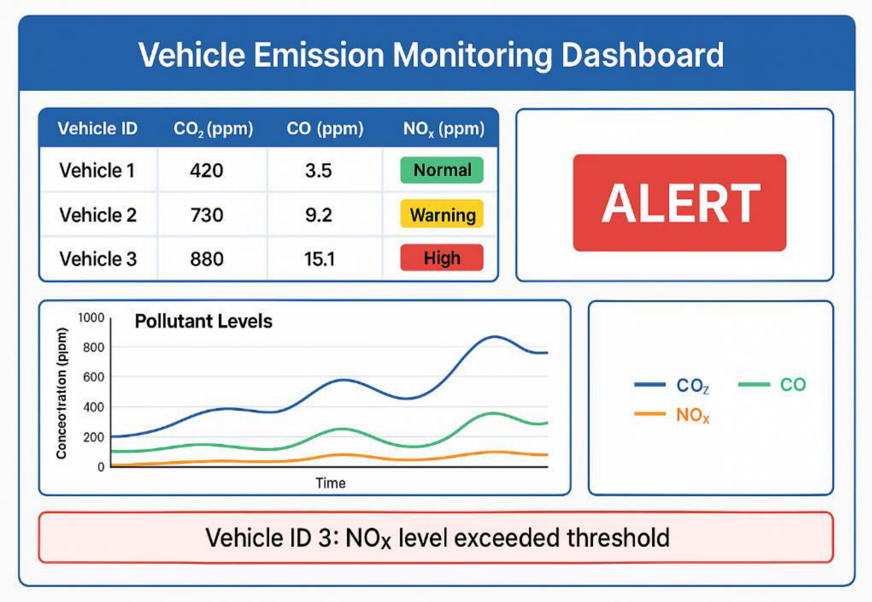
The Real-Time Vehicle Emission Detection System proved effective in monitoring emissions such as **CO_2**, **CO**, **NO_x**, and **PM2.5** using IoT sensors and AWS cloud services. The system provided accurate, real-time data, with quick transmission to **AWS IoT Core** and efficient processing through **AWS Lambda**. Alerts were triggered promptly when pollution levels exceeded thresholds and delivered via SMS, email, and app notifications.

The real-time dashboard and mobile app enabled easy monitoring of emission levels and vehicle locations. The system showed good scalability and performance, handling data from multiple vehicles without delay. Historical data stored in **AWS DynamoDB** supported trend analysis and regulatory reporting.

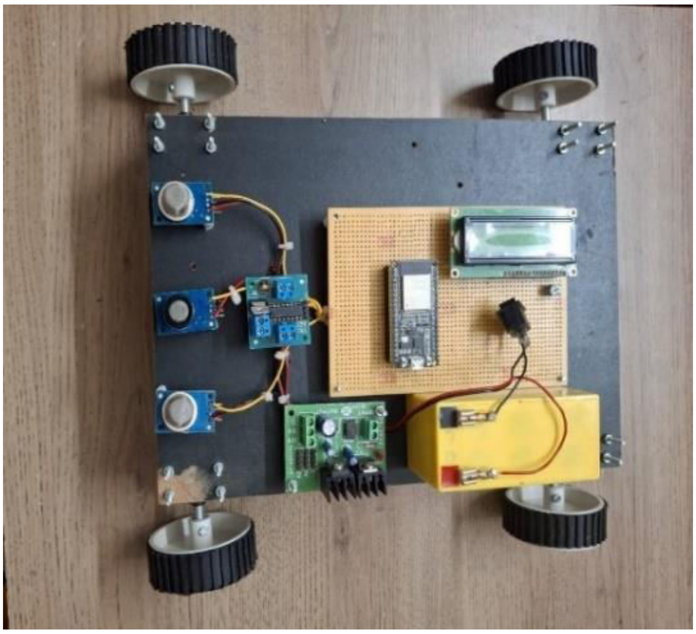
| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |



Some challenges were observed, including the need for sensor recalibration and occasional network issues in low-coverage areas. However, the system significantly improved emission tracking and supports proactive maintenance and regulatory compliance. Overall, it offers a reliable and scalable solution for reducing urban air pollution.



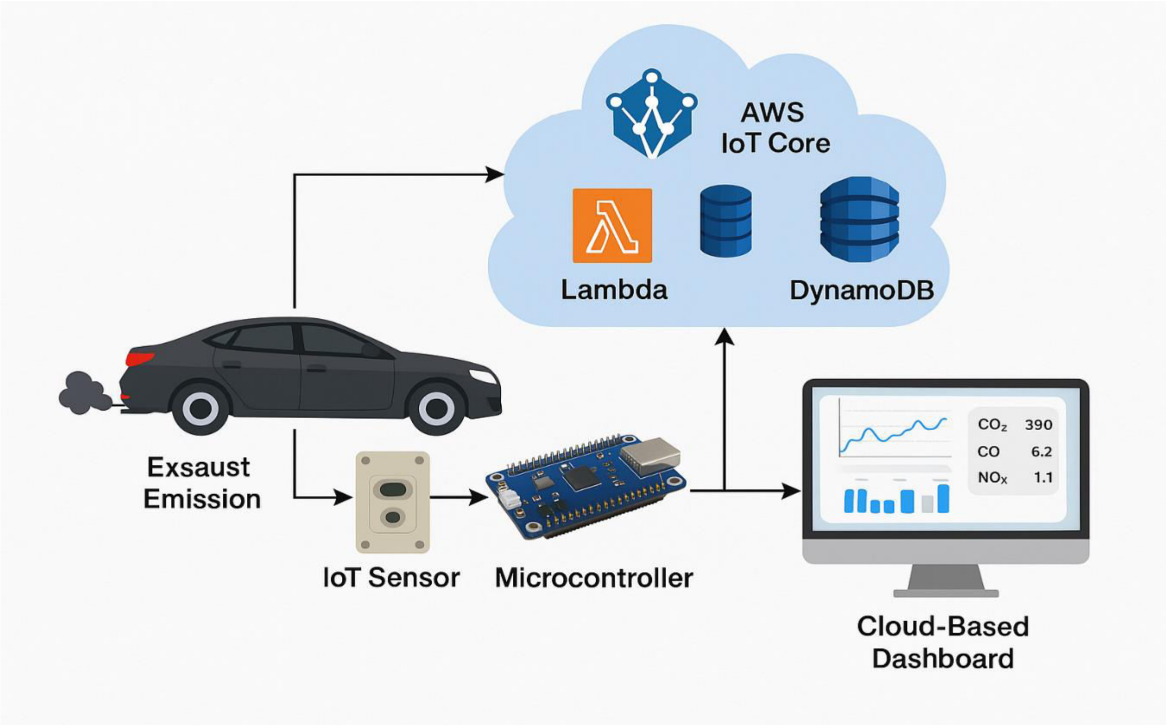
VII. CONCLUSION

The proposed Real-Time Vehicle Emission Detection System successfully integrates IoT and AWS cloud services to monitor vehicle emissions efficiently. It offers accurate, real-time data, automated alerts, and user-friendly visualization, enabling proactive pollution control and regulatory compliance. With further enhancements in sensor accuracy and connectivity, the system holds great potential to support cleaner, smarter, and more sustainable urban transportation.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 14, Issue 4, April 2025 ||

| DOI:10.15662/IJAREEIE.2025.1404038 |

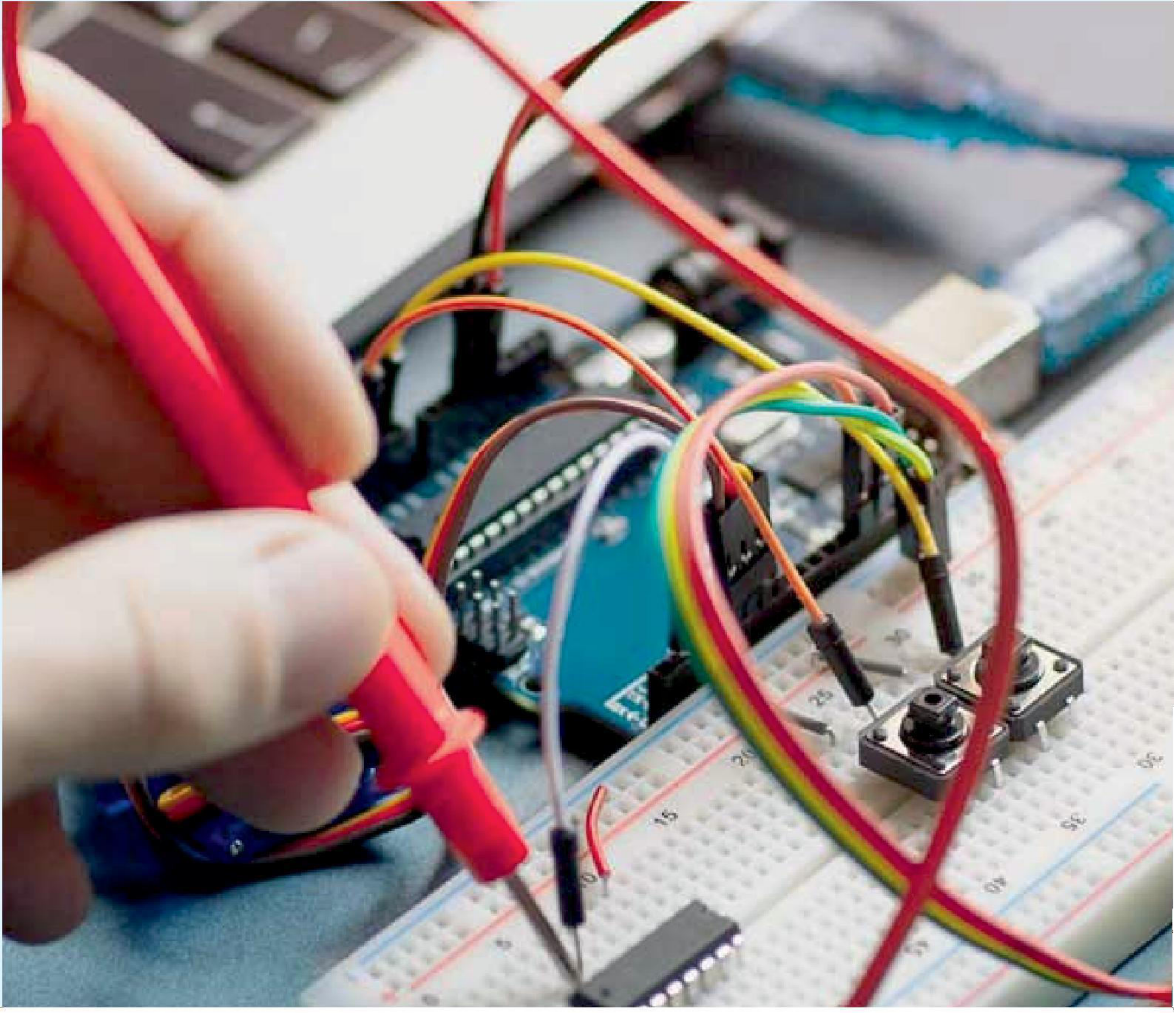


REFERENCES

1. H. Ding, M. Cai, X. Lin, T. Chen, L. Li, and Y. Liu, "RTVEMVS: Real-time modeling and visualization system for vehicle emissions on an urban road network," *Journal of Cleaner Production*, vol. 309, p. 127166, Aug. 2021.
2. M. Soufian, M. Irshaidat, M. Babaie, G. Elliott, D. Mahood, and L. Pendlebury, "Real-Time Emission Monitoring and Display to Reduce Vehicle Pollution Using Wireless Network," in *Proc. 12th Int. Conf. Developments in Systems Engineering (ICDSE)*, 2019, pp. 161–165.
3. R. S. Harish, and S. P. S. Raj, "IoT-Enabled Forecasting of Vehicle-Based Carbon Emissions and Smart Fuel Management," *International Journal of Industrial System and Applications Engineering (IJISAE)*, vol. 7, no. 3, pp. 154-160, 2021.
4. K. M. G. Nair, S. T. Santhosh, and A. R. Murali, "Detection and Real-Time Monitoring of Sulfur Dioxide Concentration from Automobile Exhaust Using IoT," *Amrita University*, 2020.

A. Kumar, R. K. Sharma, and S. P. Jain, "IoT Based Car Pollution Detection Using Cloud Computing," *International Journal of Environmental Science and Development (IJESD)*, vol. 9, no. 12, pp. 475-479, 2018.

5. S. S. Roy, M. S. Islam, and A. A. Rahman, "Vehicular Emission Monitoring and Alerting System Using IoT," *IEEE Access*, vol. 8, pp. 124364-124374, 2020.
6. S. K. Sharma, A. Kumar, and M. S. Bisht, "IoT Based Vehicle Emission Monitoring and Alerting System," *IEEE International Conference on Communication and Electronics Systems (ICCES)*, 2019, pp. 895–899.



International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering