Application of RFID technology for solving vehicle emission in cities on internet of things

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ABSTRACT

Urban areas are experiencing severe environmental pollution due to rapid growth in vehicular traffic. High levels of CO_2 and other toxic gases released from vehicles contribute significantly to poor air quality, health hazards, and environmental degradation. This paper presents an IoT-based smart vehicle emission monitoring and control system using RFID technology. The system employs RFID for vehicle identification, CO_2 and air-quality sensors for pollution measurement, and an ESP32/Arduino-based cloud-connected controller for real-time monitoring. When vehicle emissions exceed permissible limits, the system records data, uploads it to the cloud, and activates a pollution-control exhaust fan using a relay mechanism. This automated solution ensures continuous emission monitoring, reduces manual checking, and supports smart-city pollution management.

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Keyword :- *RFID Technology, IoT, Vehicle Emission Monitoring, CO_2 Sensor, Air Quality Index, ESP32, Arduino, Cloud Monitoring, Smart City.*

1.INTRODUCTION

Vehicular emissions are one of the leading causes of air pollution in metropolitan regions. Harmful exhaust gases like CO_2, CO, and NOx contribute to respiratory diseases, global warming, and environmental imbalance. Traditional emission testing is performed manually at fixed intervals, making it **inefficient and ineffective for daily pollution monitoring**.

The Internet of Things (IoT) provides an intelligent and automated approach to real-time environmental tracking**. RFID allows automatic vehicle identification**, while microcontrollers and sensors provide continuous emission measurement. Integrating these technologies enables a **smart, automated, and scalable** pollution-management infrastructure for cities.

This paper proposes an **IoT-enabled RFID-based emission monitoring** system that detects emission levels for each vehicle, analyzes real-time air quality, and performs corrective actions like activating exhaust fans when pollution rises beyond threshold levels. The solution supports smart-city frameworks by enabling instant **data accessibility and automated pollution control**

1.1 Problem statement

Rapid urbanization and the continuous increase in vehicular traffic have led to dangerously high levels of air pollution in cities. A major contributor to this problem is the emission of harmful gases such as CO_2, CO, and NOx from poorly maintained or aging vehicles. Existing emission-testing methods are performed manually at fixed intervals, making them inefficient for real-time pollution control. Authorities also lack a proper mechanism to identify high-emission vehicles instantly or monitor pollution levels in congested urban areas. Additionally, current systems rely heavily on human involvement and do not offer automated corrective action.

1.2 Objectives

- To design an IoT-based system that automatically identifies vehicles using RFID technology and monitors their emission levels in real time using CO_2 and air-quality sensors.
- To process sensor readings through Arduino/ESP32 microcontrollers and compare them with predefined emission standards for accurate pollution evaluation.
- To upload real-time emission data to the cloud using Wi-Fi connectivity, enabling remote monitoring and maintaining digital pollution records.
- To activate an exhaust fan through a relay module whenever CO_2 levels exceed safe limits, providing immediate pollution control in high-traffic zones.
- To develop a cost-effective, efficient, and scalable smart-city solution for improving urban air quality and supporting environmental regulation.

2. LITERATURE REVIEW

1.RFID Applications in Intelligent Transportation Systems

This paper discusses how RFID technology is used in modern transportation systems for vehicle identification, traffic automation, and access control. It highlights the advantages of RFID such as fast scanning, long-range detection, and high accuracy, making it suitable for real-time vehicle monitoring projects. The study also explains how RFID reduces manual errors and improves efficiency in urban mobility systems.

2. IEEE Xplore (2019) – IoT-Integrated RFID Monitoring for Smart Cities

This research presents an IoT-enabled RFID framework used in smart-city applications for automated tracking and data collection. The study demonstrates how RFID tags attached to vehicles or assets can be read by fixed or mobile readers and how the data can be processed through IoT platforms. It emphasizes RFID's role in enabling real-time monitoring, automation, and data sharing across city infrastructures.

3.RFID-Based Vehicle Tracking and Identification

The paper explores RFID usage in vehicle tracking systems, showing how RFID readers installed at checkpoints can accurately identify vehicles without human involvement. It highlights the system's effectiveness in improving security, enforcing regulations, and maintaining vehicle movement records. The study confirms RFID's reliability in harsh outdoor conditions and its potential in smart transportation applications.

4. RFID and Microcontroller-Based Monitoring Systems

This study demonstrates a low-cost RFID solution using Arduino/embedded controllers for creating automated monitoring systems. It explains how RFID readers interface with microcontrollers to identify tags, store data, and trigger programmed actions. The work shows that such systems are highly suitable for academic and prototype projects. .

3. METHODOLOGY

.**Phase 1: System Design** A complete IoT architecture is designed, consisting of the RFID system, sensor module, microcontroller, cloud interface, LCD display, and relay-controlled exhaust fan.

Phase 2: RFID Identification Vehicles are assigned RFID tags.The RFID reader scans tags when vehicles enter the monitoring area and sends the vehicle ID to the microcontroller.

Phase 3: Sensor Integration CO_2 and air-quality sensors detect pollution emitted by vehicles.
Sensors convert gas concentration into voltage signals processed by Arduino/ESP32.

Phase 4: Data Processing Microcontroller compares measured values with threshold limits.
If levels are safe → data is logged and shown on LCD.
If levels are high → corrective mechanism is activated.

Phase 5: Cloud Communication ESP32 sends emission data to the cloud via Wi-Fi.
Authorities can view real-time and past emission data remotely.

Phase 6: Pollution Control A relay activates an exhaust fan whenever CO_2 levels cross the limit.
The fan filters and circulates fresh air to reduce pollution concentration.

Phase 7: Display & Alerts LCD displays vehicle ID, CO_2 level, and pollution status (GOOD / HIGH).

3.1 BLOCK DIAGRAM

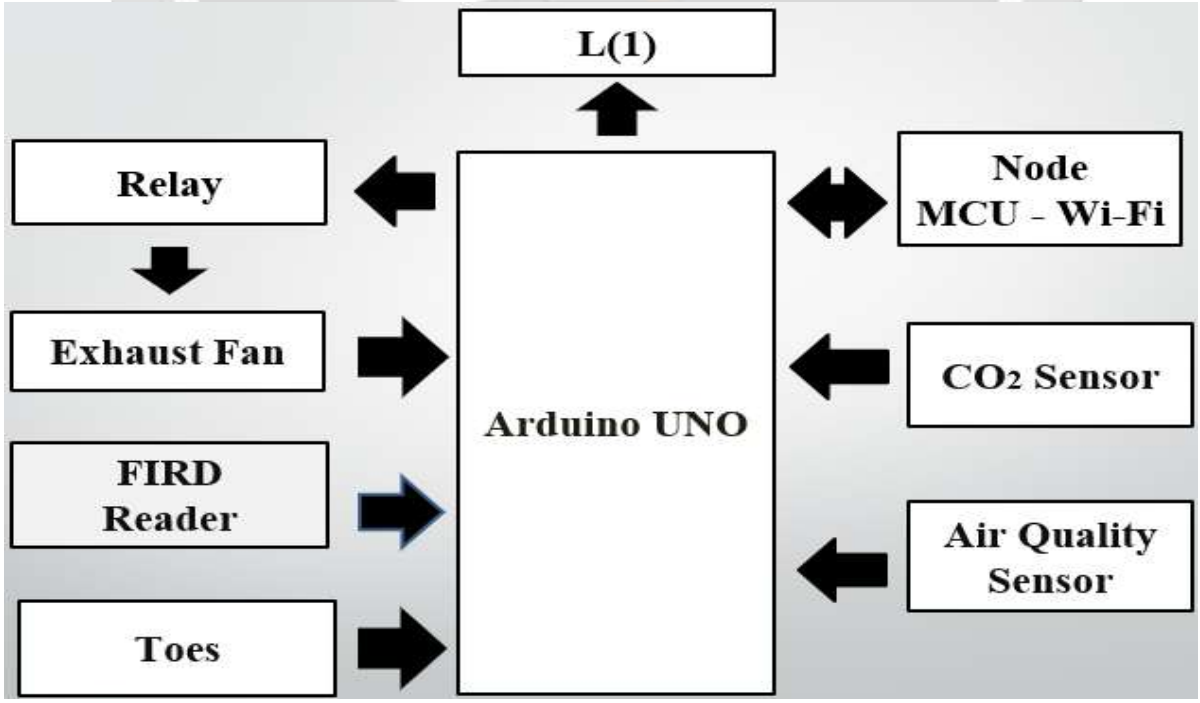

Fig-1: Block diagram

3.2 CIRCUIT DIAGRAM

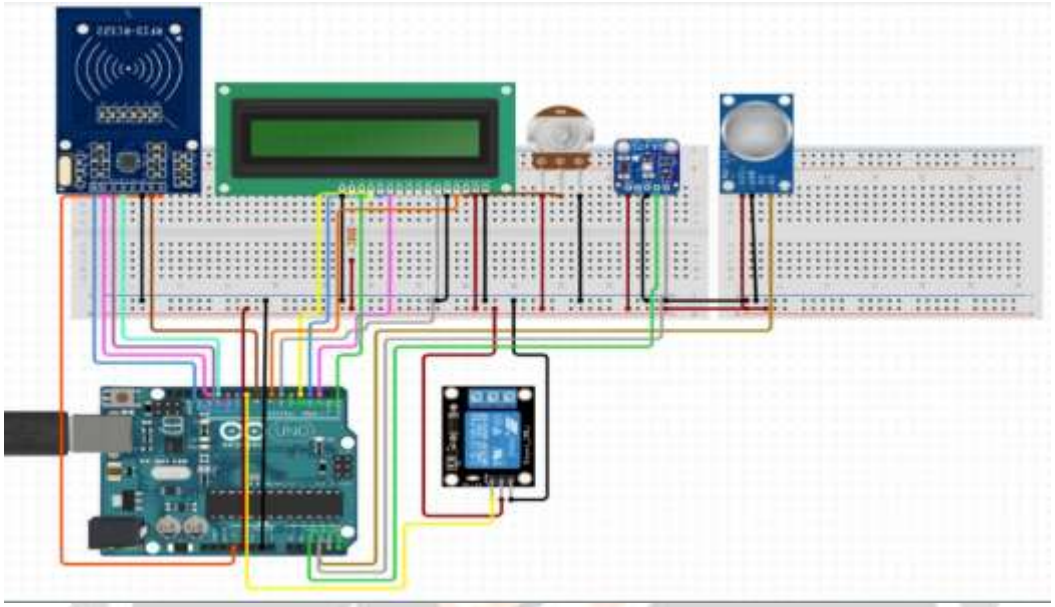

Fig -2 Circuit diagram

Sensor Nodes:

- RFID Reader → CO_2 Sensor → Air-Quality Sensor → Microcontroller (Arduino/ESP32) → Local Processing & Threshold Check → Send VehicleID + Sensor Data to Central Hub
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Central Hub:

- ESP32/NodeMCU (Wi-Fi) → Receive Data from Sensor Nodes → Compare with Thresholds → Log to Cloud & Display on LCD/OLED → Trigger Relay to Activate Exhaust Fan (if HIGH) → Send Alerts/Reports to Authorities

Vehicle Node:

• RFID Tag → Identifies Vehicle at Sensor Node → (Optional) In-Vehicle Display / Buzzer → Receive Alert (if Emission HIGH) → Driver Notification / Maintenance Prompt.

4.WORKING PRINCIPLE

The RFID-based vehicle emission monitoring system operates by combining automatic vehicle identification with real-time pollution measurement. When a vehicle enters the monitoring zone, the **RFID tag** attached to the vehicle is detected by the **RFID reader** placed at the sensor node. Once the vehicle is identified, the **CO_2 sensor and air-quality sensor** immediately measure the emission levels produced by the vehicle's exhaust. These sensor readings are sent to the **Arduino/ESP32 microcontroller**, where the values are compared with preset (safe/unsafe) emission thresholds.

If the emission values are **normal**, the data is displayed on the LCD screen and transmitted to the **central hub**, where it is uploaded to the cloud for record-keeping and further analysis. If the emission values are **high**, the microcontroller signals the **central hub**, which then activates the **relay-controlled exhaust fan** to reduce CO_2 concentration in the environment. At the same time, the system logs this high-emission event to the cloud, helping authorities track vehicles that consistently produce excessive pollution.

In optional configurations, the system can also send a warning back to the **vehicle node**, alerting the driver about high emissions and advising vehicle maintenance. The working process continues automatically for every passing vehicle, ensuring continuous, real-time monitoring without human involvement.

5.HARDWARE AND SOFTWARE REQUIREMENTS

a. HARDWARE REQUIREMENTS

- Arduino UNO
- ESP32 / NodeMCU
- RFID Reader Module
- RFID Tags
- CO_2 Sensor Module
- Air Quality Sensor
- LCD Display
- 2-Channel Relay Module
- Exhaust fan
- DC-DC Power Supply Module

b. SOFTWARE REQUIREMENTS

- Arduino IDE
- Embedded C/C++ Programming
- RFID Library
- Wi-Fi/ESP32 Libraries
- Cloud Platforms (Thingspeak, Firebase, MQTT)
- Serial Monitor for debugging

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6. RESULTS

6.1 HARDWARE INTERFACE

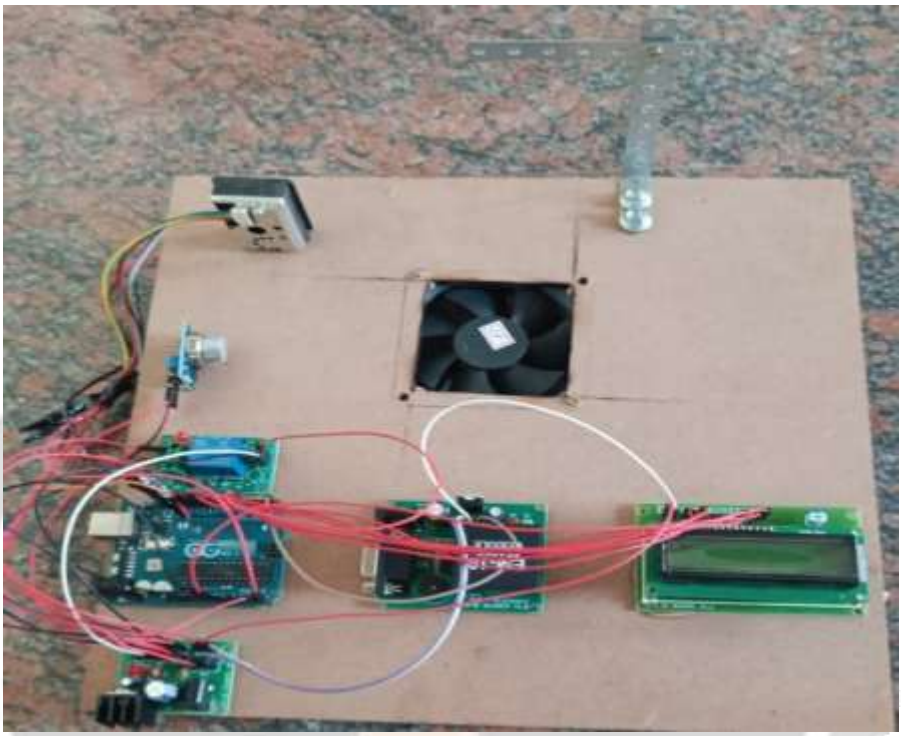

Fig-3: RFID model

This setup shows a working prototype of an RFID-based CO_2 level monitoring system built using embedded electronics. The model includes an Arduino microcontroller connected to various components, including an RFID reader for vehicle identification, gas or CO_2 sensors for emission detection, and a relay module used to control the attached exhaust fan placed at the center of the board. The LCD display on the right is used to show real-time values such as CO_2 levels, air quality, or vehicle details. The wiring connects all modules to enable communication between the sensors, Arduino, and output devices. The fan automatically or manually operates through the relay to regulate emissions when the detected values exceed the threshold, demonstrating how the system can help monitor and control vehicle pollution in a practical environment.

6.2 SOFTWARE INTERFACE

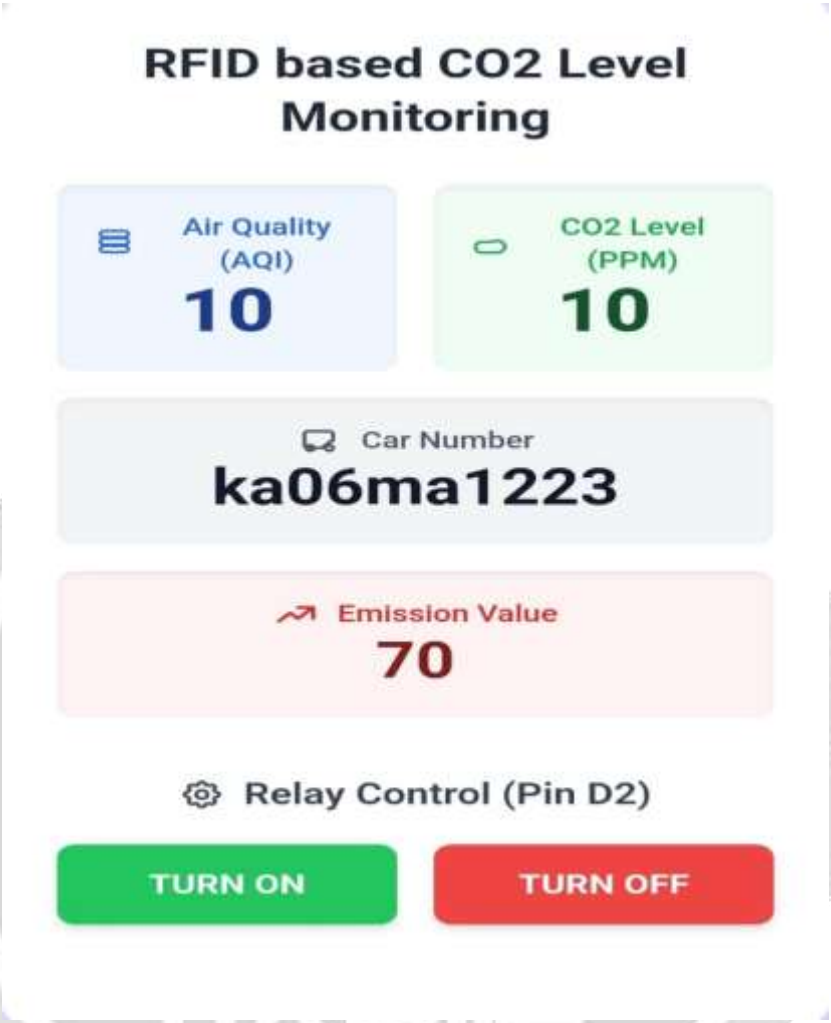

Fig-4: Software outcome

The displayed output belongs to an RFID-based CO_2 level monitoring system that tracks environmental conditions and vehicle emissions in real time. It shows an Air Quality Index (AQI) value of 10, indicating very clean air, and a CO_2 concentration of 10 PPM, which is extremely low and may reflect a controlled or demo environment. The RFID scan identifies the vehicle with the number KA06MA1223, and the emission sensor reports a value of 70, highlighted in red to indicate that it may be above the system's safe threshold. The interface also includes relay control options for Pin D2, allowing the user to manually turn connected hardware—such as a fan, exhaust system, or alert mechanism—on or off.

7. CONCLUSIONS

The integration of RFID technology within an Internet of Things (IoT) framework offers a practical and effective solution for addressing vehicle emission challenges in urban environments. By enabling real-time identification, monitoring, and data collection from vehicles, RFID systems make it possible for city authorities to track emission levels accurately and enforce compliance with environmental regulations. When combined with IoT platforms, this data can be analyzed, shared, and used to automate traffic control, support dynamic low-emission zones, and guide evidence-based policy decisions. Overall, the application of RFID and IoT not only enhances transparency and efficiency in emission management but also contributes significantly to cleaner air, smarter mobility systems, and more sustainable urban living.

8. REFERENCES

[1] Jewargi, S., & Durgale, R. (2016). RFID based Vehicle Emissions in Cities on Internet of Things. IJERT (International Journal of Engineering Research & Technology).

[2] Lolge, S. N., & Sanap, S. D. Vehicular Pollution Monitoring Using IoT. IJRASET.
IJRASET

[3] Bharathraj, P., Prasad, V. S., Kumar, M. A., & Shyamalaprasanna, A. (2022). Vehicle Pollution Monitoring System using IoT. IJERT.
IJERT

[4] .Rana, A., Rawat, A. S., Afifi, A., et al. (2022). A Long-Range IoT-Based Advanced Vehicle Pollution Monitoring System with Node Authentication and Blockchain. Applied Sciences, 12(15), 7547.
MDPI

[5] Miralavy, S. P., Atani, R. E., & Khoshrouz, N. (2019). A Wireless Sensor Network based approach to monitor and control air pollution in large urban areas. arXiv.

[6] Sliwa, B., Piatkowski, N., & Wietfeld, C. (2020). The Channel as a Traffic Sensor: Vehicle Detection and Classification based on Radio Fingerprinting. arXiv.
arXiv