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Integration of IoT and Environmental Science: Vehicle Emission Monitoring Perspective

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Abstract

Since automobiles are the primary source of environmental pollution, an increase in automobile ownership also results in an increase in air pollution. Gases such as methane, butane, LPG, smoke (MQ2), carbon monoxide (MQ7), and hydrogen gas (MQ8) are all released from the vehicle as it smokes. Cars produce around half of the MQ2, MQ7, and one-fourth of the MQ9 in our environment, which contributes to global warming. The number of gases released from an exhaust system may rise because of poor vehicle maintenance and ignition defects. We may use this technique to prolong the life of automobiles and lessen environmental pollutants. Our technology will notify the user via LCD when the rate of gases emitted from the vehicle surpasses the government-set threshold level. The emission level is additionally shown and saved in the car owner's database via IOT. The report with all the facts will be sent to the transport office if the car owner disregards it. The Node MCU Microcontroller oversees the entire system. In today's globe, pollution is a persistent environmental problem. Given that vehicle emissions are the main source of pollution, this method may be viewed as a control measure. The primary goal is to create a design that integrates the Internet of Things and an Arduino UNO to create a surveillance system that is affordable, energy-efficient, and environmentally friendly.

Keywords*:* IoT, PIC controller, gas sensor, vehicle emission, GSM

INTRODUCTION

To reduce emissions, it is necessary to utilize precise and ongoing monitoring methods due to the high level of air pollution in urban areas, which is largely driven by automobile traffic. One fifth of the total emissions of toxic gases CO, COx, and NOx in the atmosphere is the only primary cause which is contributed by road transport in India. Observing the emissions and implementing short and long term mitigation measures to prevent pollution in cities are required [1]. Adverse health effects including asthma, eye Irritation, lung disorders and consequences of fertility are the acute and chronic outcomes of traffic related air-pollution. The population living in growing urban areas have increased risk of health outcomes [2]. To address the prevention, control, and mitigation of air pollution in India, the Air (Prevention and Control of Pollution) Act was passed in 1981 and revised in 1987. Presently, the government has regulated new emission norms for monitoring the air-pollution and resulting data provides an opportunity to minimize the dreadful effects on the environment. Due to these alarming conditions, CPCB made FC renewal mandatory every year for Heavy Transport Vehicles (HTVs) and 5 years for Light Motor Vehicles (LMVs). As per the regulations, every vehicle has to undergo assessment to obtain Pollution Under Control (PUC) certificate for every 3 months. Controlling air pollution can be achieved by monitoring the Air Quality Index (AQI) by using the relevant sensors.

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The sensor data transmission and their communication are done using new techniques like IoT and Wireless Sensor Network (WSN) which paved the way to get real-time and more reliable information. The most alarming conditions occur when the vehicle emission exceeds the standard limits that can be found by improvising the way of sensing the individual vehicle outflow. For the process of monitoring the AQI, it is essential to have an accurate mobile and stationary sensing unit, using which the metro corporation will make the laws more stringent on emissions in order to reduce them. Meanwhile the use of e-vehicles in different European countries, especially Norway and Austria analyses and understands the factors influencing the competitiveness of e-vehicles and socio-economic aspects. They are also foisting the emission laws as a serious condition and conducting awareness campaigns. Even though the revenue effects of e-vehicle is insignificant in the long run, the cost of elevating a new technology in to the market is important [4]. On the other hand, developing countries like India, Brazil and South Africa are mostly depending on fossil fuels for transportation and domestic applications. In these countries, emission certificate is provided when a new vehicle is purchased but the renewal of it is ignored by most of the citizens [3]. This study focuses on the development of field instruments as a solution to spread attentiveness in each and every individual. The presented prototype in this study which comprises of micro-controller and the sensor to evaluate the vehicle emissions and communicate through GSM and to alert the government for tracking the AQI, is manifested.

LITERATURE SURVEY

The literature survey, as shown in Table 1, encompasses a diverse range of IoT-based systems aimed at monitoring and addressing vehicle emissions and air pollution. The IoT-based vehicle emission monitoring system focuses on real-time monitoring using sensors such as gas sensors, connected via IoT infrastructure. This approach offers the advantage of immediate data collection, enabling prompt responses to emission levels. However, it may incur initial costs for setup and maintenance [1]. Another proposed system utilizes RFID and cloud services at toll plazas for monitoring vehicle emissions. This approach not only promotes environmental benefits but also raises concerns regarding data security, particularly with the integration of cloud services [2]. A system integrating IoT, PIC controller, gas sensors, and GSM for emission monitoring and alerting highlights its compliance with regulations. However, privacy concerns arise due to the transmission of data via GSM networks [4]. An IoT-based air pollution prediction and monitoring system offers data-driven decision-making capabilities. However, it faces challenges in maintaining sensor calibration and overall system maintenance [5]. A system combining IoT with machine learning for air quality monitoring promises cost savings but risks data overload, potentially overwhelming the system's processing capabilities [3]. An IoT-based vehicle emission monitoring system with pollution detection emphasizes fleet management benefits but may encounter compatibility issues with existing vehicle systems [6].

Lastly, a vehicular air purifier employing IoT and AI aims to raise public awareness and prevent air pollution. However, it may generate false alarms, impacting its reliability.

Table 1. Literature survey.

Sr. No.	Title	Methodology	Pro's	Con's
1.	IoT Based Vehicle Emission Monitoring System [7]	Smoke, IoT, gas sensor, LCD, Node MCU.	Real-Time Monitoring	Initial Cost
2.	IOT Based vehicle emission at toll plaza using RFID and Cloud Services [8]	Arduino Uno, Wi-Fi module, sensor, Thingspeak	Environmental Benefits	Data Security
3.	IoT Based Vehicle Emission Monitoring and Alerting System [9]	IoT, PIC controller, Gas Sensor, Vehicle Emission, GSM	Compliance and Regulations	Privacy Concerns
4.	Internet of Things	Health effects; IoT platform; Sensor	Data-Driven	Maintenance

	based air pollution prediction and monitoring system [10].	calibration; Alarming unit	Decision Making	Challenges
5.	IoT-Based Air Quality Monitoring System with Machine Learning for Accurate and Real-time Data Analysis [11]	Sensors, wi-fi module, Thingspeak	Cost Savings	Data Overload
6.	Monitoring and Detection of Vehicle Emissions on Steady State [12]	Internet of Things, Vehicle Emission Monitoring System	Fleet Management	Compatibility Issues
7.	Vehicular Air Purifier: IoT Enabled System with Artificial Intelligence to Prevent Air Pollution [13].	Air pollution, Artificial Intelligence, Machine Learning, MQ135, Arduino Tools, Support vector regression, Air Quality Index, Sensors, IoT	Public Awareness	False Alarms

SYSTEM DESIGN

Block diagram of flow of information is shown in Figure 1.

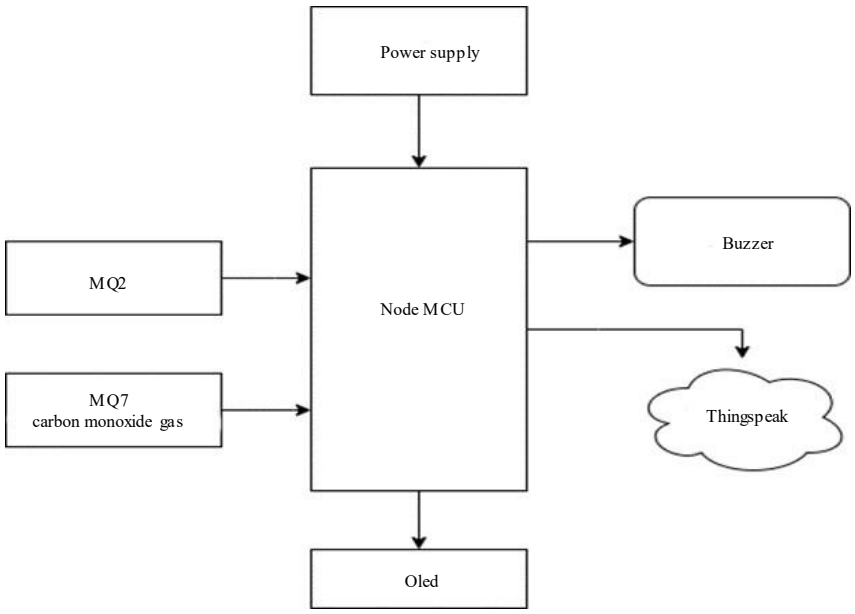

Figure 1. Block diagram of flow of information.

An IoT-based vehicle emission monitoring system integrates several essential components to monitor and manage vehicle emissions effectively. At its core, this system utilizes ESP8266 Node MCU as a central controller, supported by a power supply ensuring continuous operation. It employs various

sensors, including LPG gas, Carbon monoxide gas, strategically placed in a vehicle's exhaust system to measure emissions in real-time. The data collected by these sensors is processed by the Node MCU, which also controls an OLED display, providing real-time emission information. Internet connectivity enables seamless communication with a remote server or cloud platform, where the data is transmitted for storage and analysis. Advanced analytics and machine learning algorithms on the cloud can evaluate emission patterns and standard compliance. If emissions exceed permissible limits, the system triggers alerts, notifying vehicle owners, fleet managers, and regulatory bodies. Additionally, cloud-based data access facilitates remote diagnostics and maintenance scheduling, ultimately promoting cleaner air, vehicle health, and regulatory adherence.

Components Used

MQ-2 LPG: The gas sensor module is intended to identify liquefied petroleum gas (LPG) in the atmosphere. It operates on the principle of chemiresistive technology, where its sensing element changes resistance when exposed to LPG gas. An analog output voltage proportionate to the LPG concentration is produced by the sensor module, which normally runs at 5 V DC. It is widely utilized in industrial safety applications, gas leak detection systems, and settings where LPG level monitoring is essential for worker safety. Smoke Sensor is shown in Figure 2.

Figure 2. Smoke sensor.

Carbon monoxide sensor: Carbon monoxide (CO) sensors, as shown in Figure 3, are essential in assessing the emissions from vehicles, particularly their impact on air quality and public health. These sensors identify hazardous gas created by internal combustion engines, known as CO, when it is present. By measuring CO levels, the system can provide insights into the emission levels and air pollution due to vehicle exhaust, contributing to more effective pollution control and mitigation.

Figure 3. Carbon monoxide sensor.

Node MCU microcontroller: The NodeMCU microcontroller, as shown in Figure 4, is the heart of the system, serving as the central processing unit that collects, processes, and transmits data from the sensors to the cloud or a monitoring platform. NodeMCU facilitates data integration and connectivity, making it a vital component for real-time monitoring and control.

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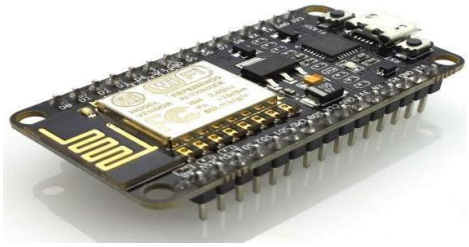

Figure 4. Node MCU microcontroller.

OLED display: An OLED (Organic Light Emitting Diode) display, as shown in Figure 5, is often used to provide a user-friendly interface for the system. It offers real-time visualization of data, allowing users to monitor emission levels directly. This display enhances the system's usability and accessibility.

Figure 5. OLED display.

Buzzer: A buzzer, as shown in Figure 6, is a small electronic device that produces sound when an electrical current is passed through it. It typically consists of a coil of wire and a magnet, which when energized, causes the magnet to vibrate rapidly, creating a buzzing or beeping sound. Buzzer is commonly used in various applications such as alarms, notifications, and electronic games to provide audible alerts or signals.

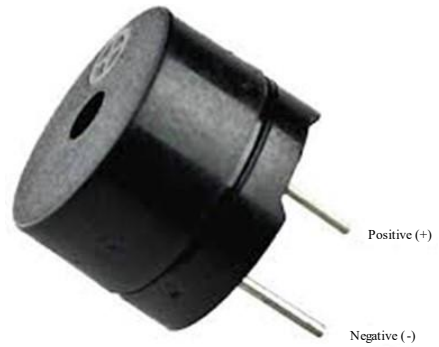

Figure 6. Buzzer.

IMPLEMENTATION

The vehicle emission system flow chart begins with the activation of the Node MCU microcontroller, which initializes the system and establishes connectivity with the MQ2 and MQ7 gas sensors. As the sensors are powered up, they start monitoring the surrounding air for the presence of harmful gases, such as carbon monoxide (CO) and methane (CH_4). Upon detection of these gases, the sensors send analog voltage signals proportional to the gas concentration to the Node MCU for processing. The Node MCU then interprets these signals and converts them into meaningful data representing the level of emissions. Subsequently, the OLED display connected to the Node MCU is updated with real-time emission data, providing visual feedback to the user. Simultaneously, the Node MCU transmits this data to the ThinkSpeak server via Wi-Fi for remote monitoring and analysis. If the emission levels exceed predefined thresholds, the system activates a buzzer alarm to alert nearby individuals or authorities about the elevated pollution levels. Overall, this flow chart illustrates the seamless operation of the vehicle emission monitoring system, integrating MQ2 and MQ7 sensors, Node MCU microcontroller, OLED display, and Think Speak server to effectively monitor and manage vehicle emissions in real-time. Flow Chart of the whole process is shown in Figure 7.

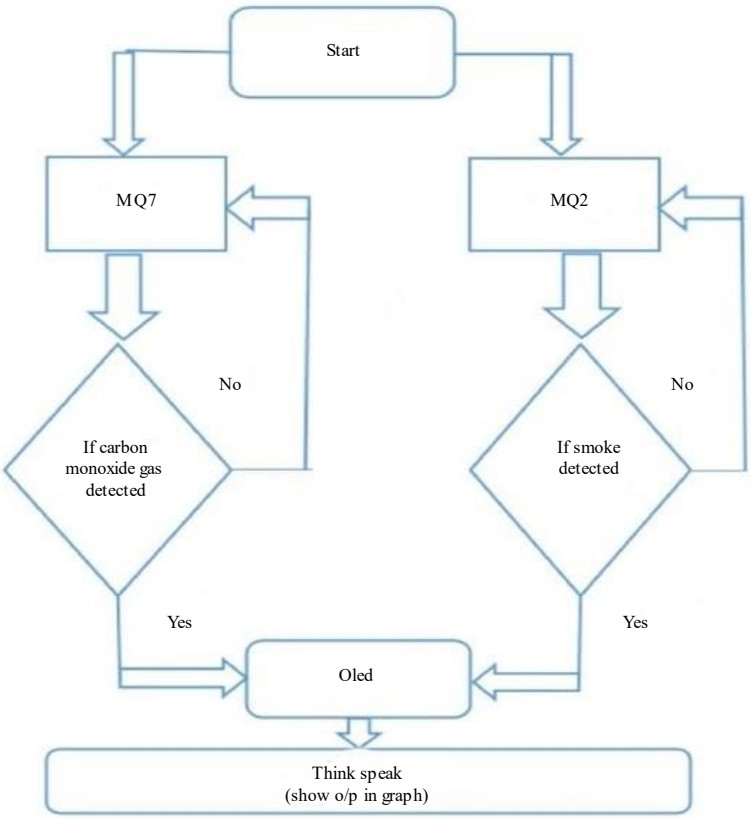

Figure 7. Flow Chart of whole process.

RESULTS

Upper view of circuit diagram is shown in Figure 8. While Code and Output of sensors showing an

Arduino IDE and results are shown in Figures 9 and 10 respectively. Figure 11 shows OLED output of both the sensors.

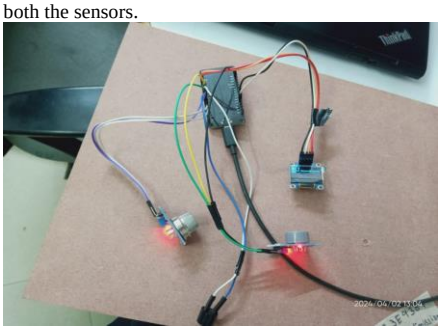

Figure 8. Sensors connected to Node MCU.

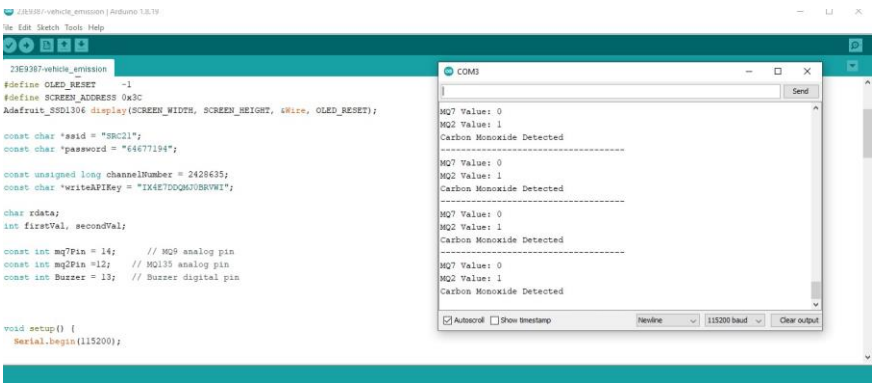

Figure 9. Code and output of sensors showing on Arduino IDE.

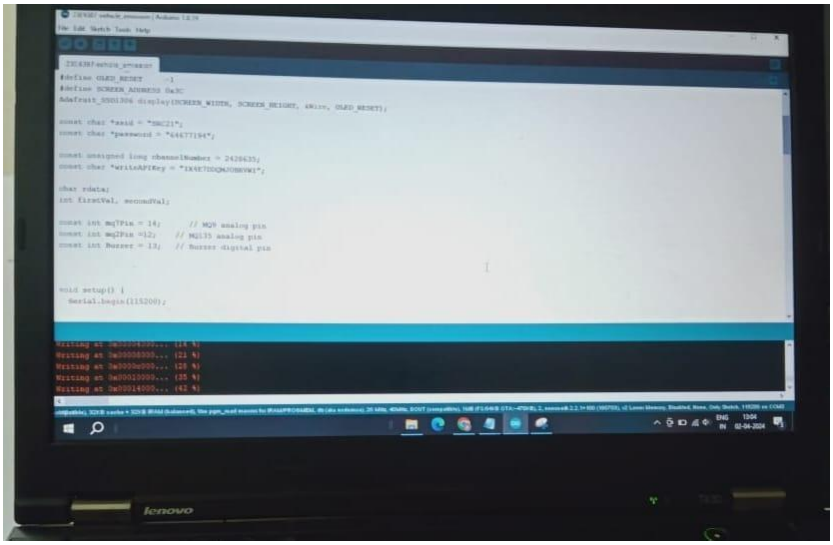

Figure 10. Result showing on Arduino IDE.

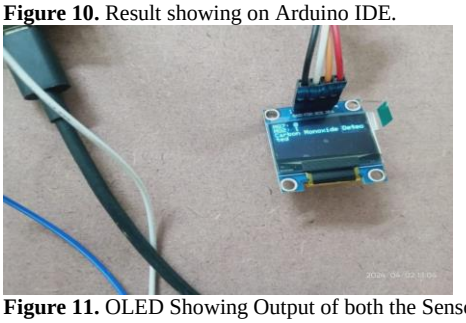

Figure 11. OLED Showing Output of both the Sensors.

CONCLUSION

In conclusion, IoT-based Vehicle Emission Monitoring Systems offer a transformative solution to the persistent challenges of air pollution and emissions control in the transportation sector. These systems harness the capabilities of the Internet of Things to provide real-time, data-driven insights into vehicle emissions. The advantages they bring to the table are profound, encompassing improved air quality, regulatory compliance, cost savings, and enhanced public health. By enabling the continuous monitoring and management of vehicle emissions, IoT-based systems not only help mitigate the environmental impact of transportation but also pave the way for smarter, more sustainable urban mobility solutions. As we move towards a more environmentally conscious and technologically advanced future, these systems will undoubtedly continue to play a pivotal role in shaping cleaner and greener cities.

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