Air Quality Monitoring System for Vehicles using Cloud Green IoT

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Abstract

Every vehicle releases gases of its own, but improper vehicle maintenance causes pollutants such as carbon monoxide, nitrogen dioxide, and sulfur dioxide to be released. The pollutants generated by the emissions are a major contributor to global warming and cause serious health and visual problems. The aim of this paper is to use a waspmote sensor system near the vehicle's exhaust to track and regulate pollutant emissions from the vehicle. The pollution control circuit is made up of a number of sensors, including a smoke sensor, a temperature sensor, and wireless communication devices, all of which are integrated and linked to a controller. The vehicle's emission level is continuously monitored, and if it exceeds the standard threshold pollution level, a short message service (SMS) is created and sent through the Global System for Mobile communications (GSM) module to a pre-defined number stored in the memory. The Global Positioning System (GPS) module is used to identify the vehicle's current location, after which the administrator takes the appropriate actions

Keywords— green IoT, air quality monitoring system, waspmote sensor

INTRODUCTION

Poor air quality is one of the leading causes of premature death, and several epidemiological studies have found a correlation between exposure above defined limits and disease burden. These and other factors have resulted in a greater and more immediate need to track and, as a result, reduce personal exposure to harmful pollutants [1–3]. Different governmental organizations around the world are working together to limit anthropogenic pollution through legislation and policies.Citizens are more mindful of and sensitive to their personal exposure to polluting agents and environments these days, and are more likely to follow safer living, transportation, energy generation, and heating solutions. Individual use of personal exposure monitoring systems thus has many benefits and is driven by a desire to make healthy decisions in daily life on a regular basis. With the currently available centralized or public network of monitoring stations, access to high resolution data of personal exposure with high spatial and time precision is difficult to achieve. However, there is still a need in the industry for a more lightweight multi-sensor air quality monitoring device that is portable.

The Internet of Things (IoT) is a collection of interconnected devices that can capture and share data. Connected devices can include embedded electronics, sensors, and network connectivity, allowing them to communicate with and collaborate with other IoT devices. Smart lighting, water, electricity, cooling, and alarm systems are examples of IoT applications in automobiles and city infrastructure [4–8]. Many research programme and community-based initiatives focus on air quality monitoring. For many cities around the world, air quality has become a big concern [9]. The Internet of Things (IoT) and wireless sensor networks have been used in a variety of research projects to measure air quality [10–12]. These projects include using stationary or mobile sensors to test various forms of pollutants in the air.

Libelium, a company that provides various types of sensors, radio technology, software development kits, and application programming interfaces for sensor network development, developed the waspmote platform.The paper [13] focused on defining essential operations and developing a setup for power consumption measurements in wireless sensor networks as well as a wireless air quality monitoring system. On an Arduino platform, the device was created to measure air quality using a network gateway to link the sensor nodes to the Internet [14]. Another project [15] used an autonomous wheeled rover with GPS cameras, three axis gyros, accelerometers, and magnetometers to track air quality.

The vehicle would immediately stop in the current system because the fuel supply has been halted, which may be dangerous if that individual were involved in an accident. It also has drawbacks, such as the

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possibility that if the sensor is held in the vehicle's exhaust, it will melt due to the heat sensation. In this paper, we consider the use of vehicle-mounted sensors, which provide greater coverage throughout the city as well as more options and versatility in route selection. Carbon monoxide (CO), Nitrogen dioxide (NO_2), and Sulfur dioxide (SO_2) are identified from a vehicle's exhaust in the proposed system by placing a waspmote sensor unit near the exhaust, and the sensor's data is then sent to the Green-IoT cloud through the mobile network. The Green IoT cloud is used for data collection, processing, and visualization in this paper, and the sensors on the vehicles communicate with the Green IoT cloud server through 4G connectivity and Hypertext Transfer Protocol (HTTP) in the application layer. The following is the order in which this paper will be presented: The proposed methodology for air quality detection and control is defined in Section II. The installation of an air quality monitoring system and the experimental results are described in Section III. The result is seen in Section IV.

METHODOLOGY

The Green IoT project aims to create creative applications based on open data generated by the Green IoT framework by conducting research on an energy-efficient IoT platform for the general public [16]. Fig. 1 shows the architecture design of the Green IoT system. Stationary sensors communicate with a sensor gateway over low-power wireless personal area networks using IPv6, a low-energy network protocol. The sensor gateway uses a Wi-Fi link to send sensor data to the Green IoT cloud in sensor markup language format. The data is stored in the cloud in a Not Only Structured Query Language (NoSQL) database and distributed through a Message Queuing Telemetry Transport Broker. The data is stored into MongoDB collections using SenMLformat which is a regular JavaScript Object Notation with a pre-agreed structure. The cloud also offers a HTTP API that enables user applications to access the database's Green IoT sensor data. The Green IoT cloud is used for data collection, processing, and visualization, and sensors on city vehicles communicate with the Green IoT cloud server through 4G connectivity and HTTP in the application layer.

Fig. 2 shows a schematic representation of the mobile monitoring system's activity. This device consists of a sensor unit installed on a vehicle and a WWW server that has been set up with a database for collecting and processing measurement data. The concentrations of chemical compounds that pollute the atmosphere are transmitted to a WWW server located anywhere via radio, the mobile GSM/GPRS network, and the Internet network. These data are analyzed and checked for authenticity there. They are then sorted by measurement data and, if appropriate, displayed on the computer of an approved user using a regular WWW web browser.

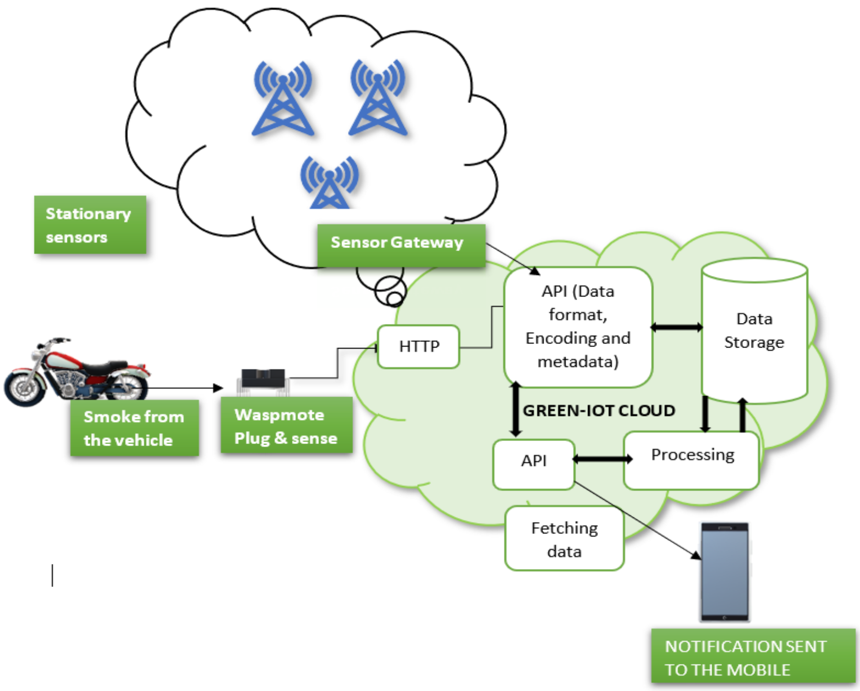

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Fig. 1. The system layout of the Green IoT

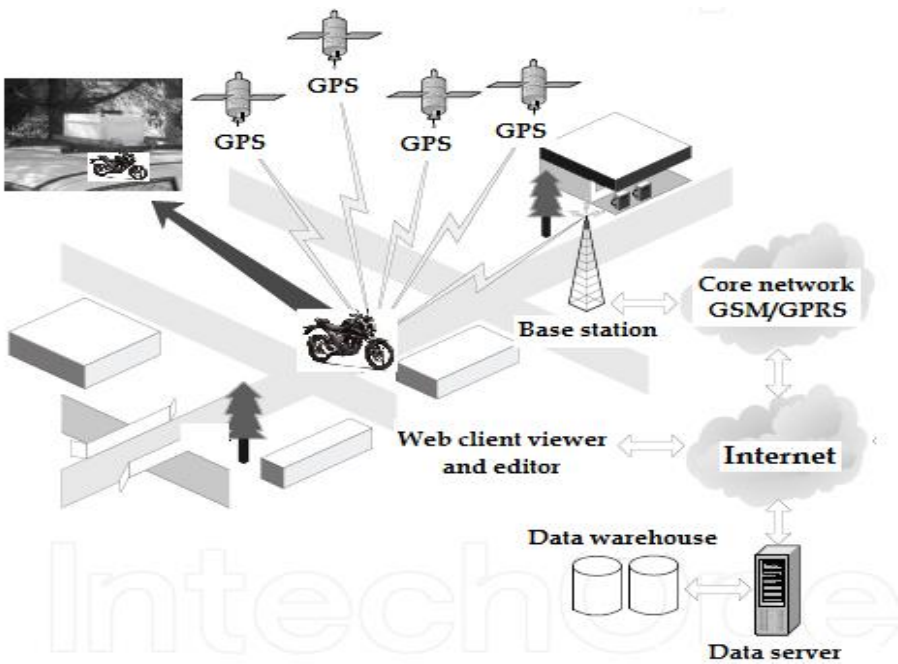

Fig. 2. The mobile monitoring system for pollutants control

Fig. 3 shows a schematic flow chart representation of the air quality monitoring system's activity. CO, NO_2, and $SO_2$are detected from a vehicle's exhaust in the proposed system by placing a waspmote sensor device near the exhaust, and the sensor's data is then sent to the Green IoT cloud through the mobile network. A stationary sensor will be mounted in one area of the city and will be connected to the Green IoT cloud via IPv6 protocol via a sensor gateway. The emission level and the regular level will be compared in Green cloud results. It will send a warning message to the user if the emitting level reaches the normal level. The emission control board will also be notified, and GPS will be used to monitor the vehicle's location. If the owner of the vehicle reaches thislimit more than three times, a fine will be levied. If this happens again, the vehicle will eventually be confiscated. Accuracy, cost-effectiveness, interoperability, and collaboration are all benefits of the proposed system. The proposed work entails identifying a series of routes that will provide comprehensive coverage of the town while still passing through highly contaminated areas that need special attention.

IMPLEMENTATION AND EXPERIMENT RESULTS

Sensing, measuring, tracking, and processing are all part of the overall framework. Waspmote is a sensor interface that can be used to build IoT projects, which is shown in Fig. 4 (a). Waspmote's hardware architecture was created with the aim of using very little electricity. It's an open source wireless sensor platform with low power consumption architecture. Waspmote can read information from any industrial system connected to the vehicles and obtain data from more than 70 sensors currently incorporated in the platform using specific sensor boards.

The sensor code must be dependable and stable, and it must not necessitate regular maintenance and inspections. The efficient code was created by modifying some of the waspmote IDE's reliable example codes and introducing more advanced functions. There are two functions in the waspmote IDE: setup and loop. Only after turning on the power or restarting the sensor does the setup feature run. It can only be used once. It formats the SD card, sets the sensor's node ID, and initializes the Real Time Clock (RTC). The RTC is used to submit the time difference between sensor start and measurement time. When sending measurements to the Green IOT cloud, the node ID is used as an identification name for the sensor.

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The loop function is named after the setup function and continues to run in a loop until the sensor's power is switched off. The CO and NO_2 functions are switched on first in the loop function to warm up, and the rest of the sensors are turned off by setting the sensor to sleep mode. Every two minutes, the sensor is woken up by the RTC. The GPS module is included in the 4G module of the waspmote plug and sense. As a result, the 4G module is enabled in order to obtain the GPS coordinates. The sensor stores the data in a PHP request string and attempts to send it to the Green IOT cloud after obtaining the GPS coordinates. Figaro's TGS2442 CO sensor, TGS2106 NO_2 sensor, and FECS43-20 SO_2 sensor are used in prototypes of sensor units for proposed systems. The hardware implementation of proposed air quality monitoring system is shown in Fig. 4 (b).

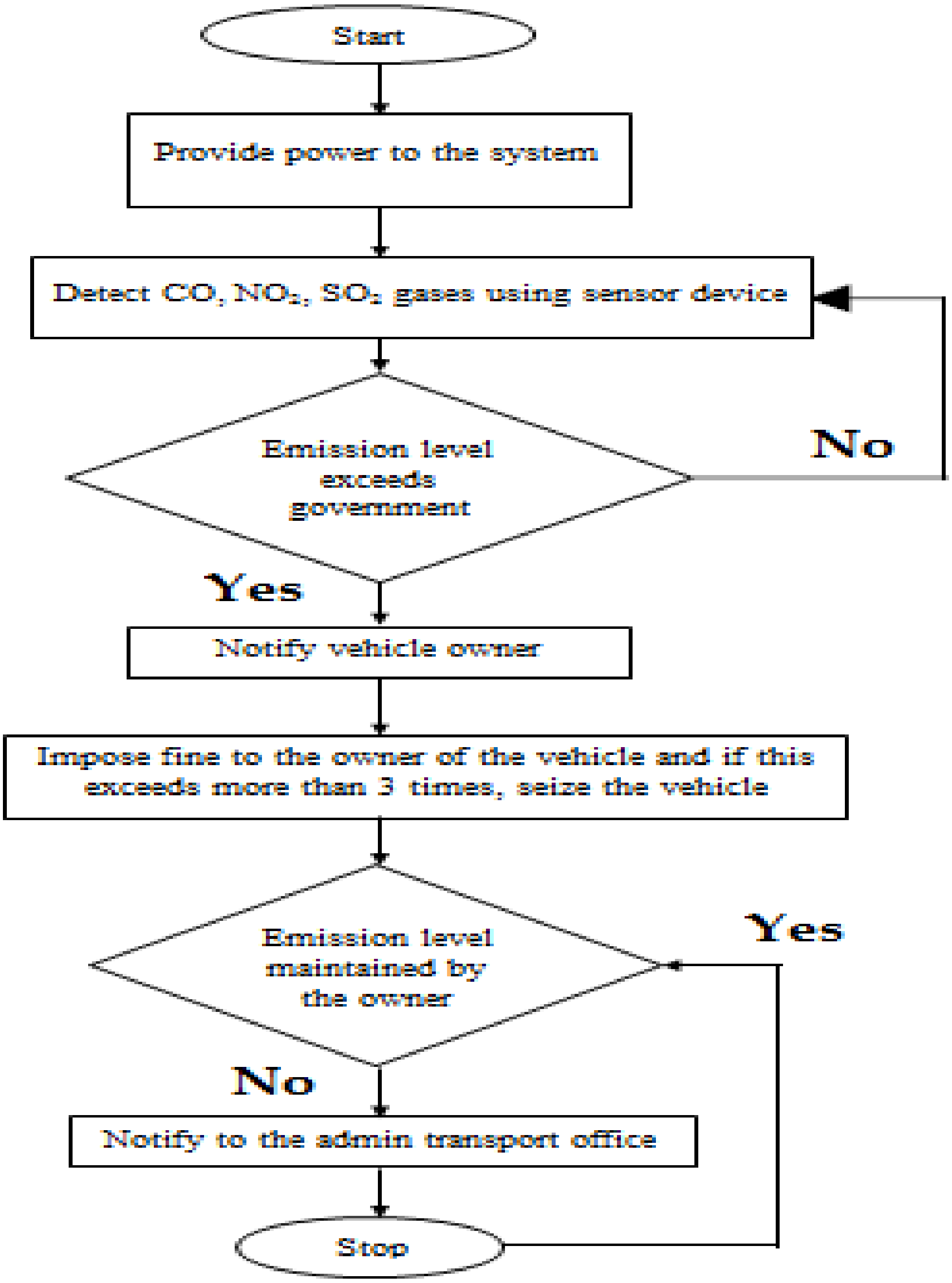

Fig. 1. Flow chart representation of air quality tracking system

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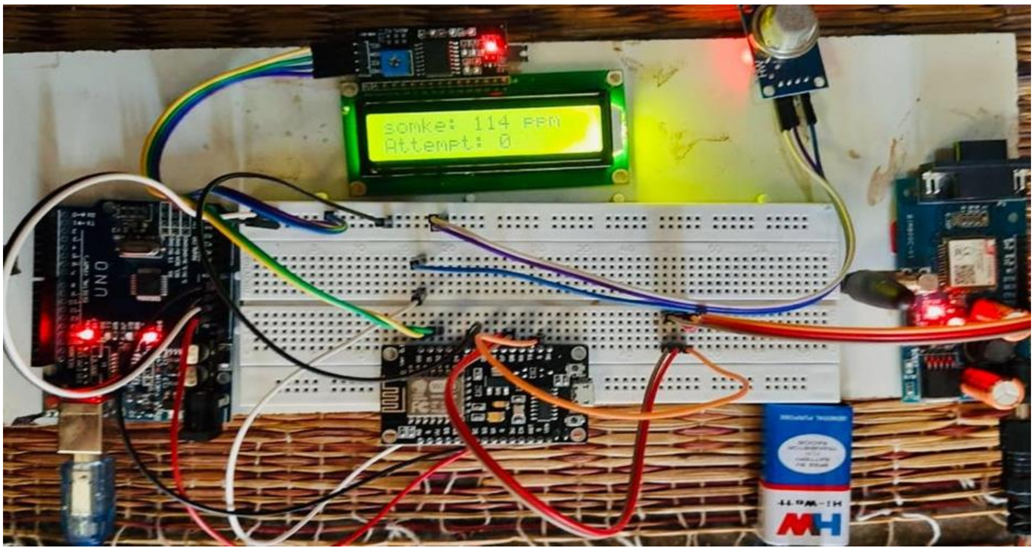
(a)



(b)

Fig. 4. Proposed system hardware (a) Waspmote plug & sense (b) Hardware implementation of air quality monitoring system

A smoke sensor, a temperature sensor, and wireless communication devices are all combined and connected to a controller in the pollution control circuit. Fig. 5 depicts the Figaro's TGS2442 CO sensor code execution process. When the vehicle's emission level reaches the standard threshold pollution level (250 ppm), the sensors on the vehicle communicate with the Green IoT cloud server through 4G connectivity and HTTP in the application layer. A SMS is generated and sent to a pre-defined number stored in the memory through the GSM module. The GPS module is used to determine the current location of the vehicle, after which the administrator takes the necessary actions. As shown in Fig. 6, the pollution control board will be informed, and GPS will be used to monitor the vehicle's location. A fine will be imposed if the owner of the vehicle exceeds this limit three times. If this occurs again, the vehicle will be seized.

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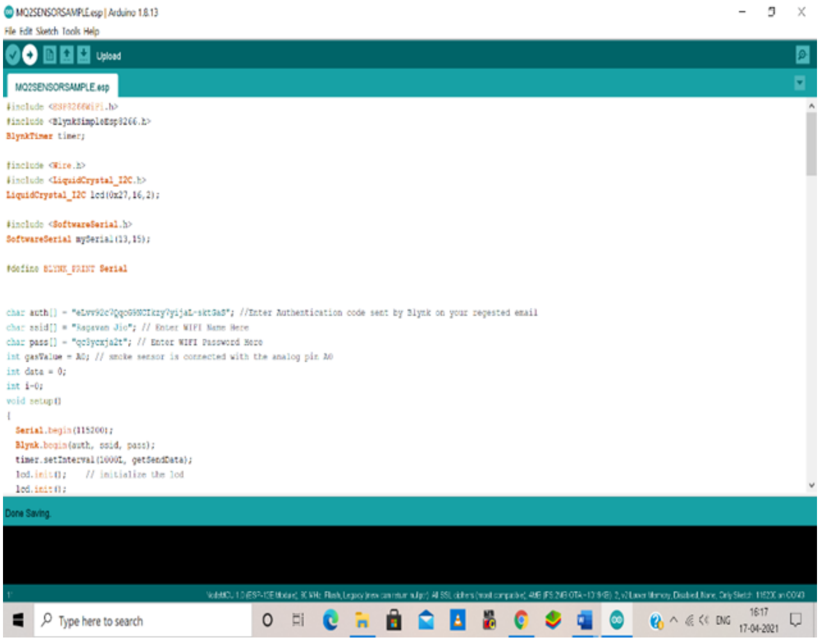

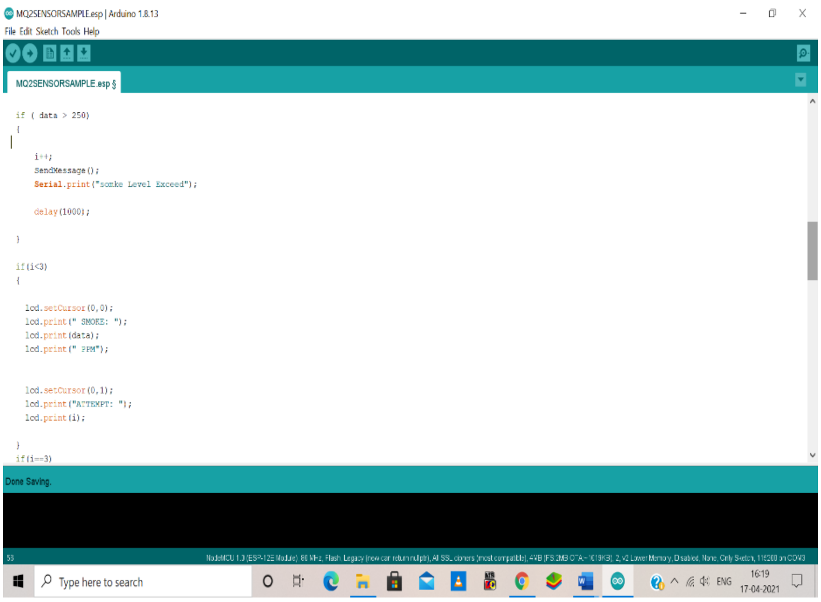

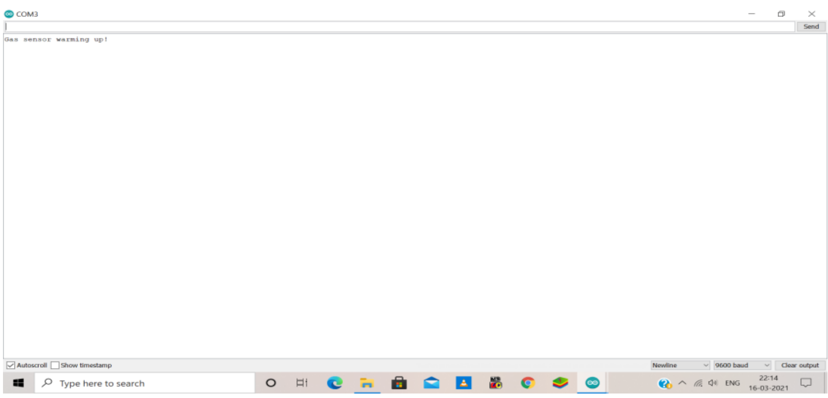

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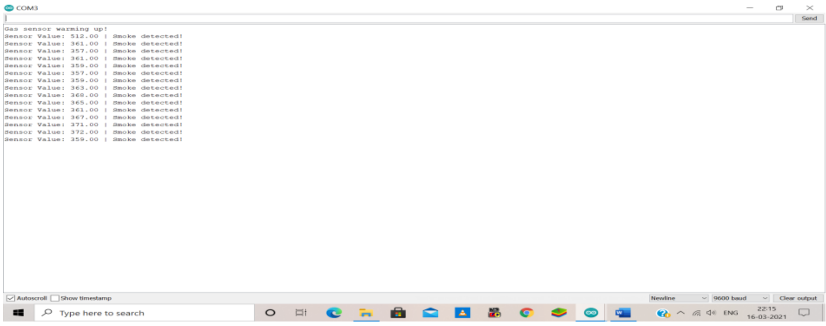

Fig. 5. TGS2442 CO sensor code execution process

Fig. 6. SMS Notification to the vehicle owner

TABLE I shows the threshold gas emission level in PPM, used in the proposed air quality monitoring system.

TABLE I. THRESHOLD GAS EMISSION LEVEL (IN PPM)

Substance	***Chemical***	***Threshold Emission level (PPM)***
Carbon	CO	250
Nitrogen	NO_2	150
Sulfur dioxide	SO_2	150

CONCLUSION

The development and implementation of a movable sensor air quality monitoring system were carried out. An air quality sensor was mounted on the public transportation vehicle as part of the system. This work was carried out as part of the Green IoT initiative, which also included the installation of other stationary sensors in the region. The CO sensor probe worked as intended, but the NO_2 and SO_2 sensor only measured non-zero concentrations with a one percent success rate, which is possibly due to its low sensitivity. The data was sent over a 4G mobile network, which had a 70% success rate without having to resend it. With the storage and re-transmission functions in operation, this performance rate improved to 100%.

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