Proceedings of the Fourth International Conference on Smart Systems and Inventive Technology (ICSSIT-2022)
IEEE Xplore Part Number: CFP22P17-ART; ISBN: 978-1-6654-0118-0

Internet of Things based Detection and Analysis of Harmful Vehicular Emissions

Akhila R[1], Amoghavarsha BM [2], Karthik BC[3], Prajwal YM[4] and Bajarangbali[5]

akilanikitha003@gmail.com[1], amogh0099@gmail.com[2], karthikbcreddy@gmail.com[3], prajwal5792@gmail.com[4], bajarangreddy@pes.edu[5]

Department of Electronics and Communication Engineering
PES University, EC Campus, Bangalore 560 100

2022 4th International Conference on Smart Systems and Inventive Technology (ICSSIT) | 978-1-6654-0118-0/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICSSIT53264.2022.9716558

Abstract – **In this paper, real time implementation of detection of harmful vehicular emissions is proposed along with its analysis. The major source for the increase of air pollution in urban areas, especially in developing countries like India, is due to the large number of transportation vehicles. Of all the major emission releases from these vehicles, which is of particular concern is Carbon Monoxide (CO). At very high levels, CO can cause dizziness, unconsciousness and even death. It is therefore very important to keep an eye on the CO levels emitted by the vehicles. The designed prototype measures CO and Smoke (Particulate Matter) emission levels through a real-time process using a semiconductor gas sensor, that is, MQ-7 gas sensor mounted on the vehicle exhaust pipe. The heart of the project is the ESP8266 microcontroller (Wi-Fi module), to which the MQ-7 gas sensor is connected. The data collected in practice is verified against standard limits and provides information to the vehicle user and relevant authorities such as Regional Transport Office (RTO), Central Pollution Control Board (CPCB) via the Global System for Mobile Communication (GSM) technology and the ThingSpeak IoT analytics cloud platform for further analysis.**

***Keywords –emission detection, emission analysis, Internet of Things (IoT), gas sensor, microcontroller, GSM module, voltage step-up module, analytics cloud platform*.**

I. INTRODUCTION

In this fast-growing world, transportation plays a vital role. Often, we can see new developments in the automobile industry. However, most of these developments focus only on the comfort of the user. In terms of environmental pollution control, very little is being improved over time. The major source of air pollution in urban areas, especially in developing countries like India is due to the large number of vehicles. Of all major emissions, the one with particular concern is Carbon Monoxide (CO). Respiratory air with high CO concentration reduces the amount of oxygen that can be transported in the bloodstream to critical organs such as the heart and brain. At very high levels, Carbon Monoxide (CO) poisoning can cause dizziness, unconsciousness and even death. It is therefore very important to keep an eye on the CO levels emitted by vehicles. The Union Government of India has been emphasizing the need to plan and develop strategies to implement measures to maintain urban air quality and to keep the cities clean and green in order to achieve better air quality and better health for the citizens. Vehicular pollution control methods in India can broadly be divided into Technical Measures and Non-Technical Measures. Technical instruments include the use of complex extraction methods for new and used vehicles, improvements in automotive technology, improving fuel quality, switching to clean and green fuel vehicles, etc. Non-technical instruments include measures such as better vehicle control system, expansion of public transport system, implementation of market-based instruments i.e., financial instruments, public information, adultery testing machines, etc.

II. LITERATURE SURVEY AND RELATED WORKS

Air pollution is one of the major environmental problems in urban areas where many people are exposed to poor air quality. The rapid urbanization in India has resulted in a dramatic increase in the number of vehicles. While the most important pollutants in petrol vehicles are hydrocarbons and carbon monoxide, the main pollutants from diesel-powered vehicles are nitrogen oxides and particulates. Vehicle emissions have devastating effects on human health. The following table (Table. 1) gives an idea about various pollutants and its effects on human health [1].

Pollutant	Effect on Human Health
Carbon Monoxide	Affects the cardiovascular system, exacerbating cardiovascular disease symptoms, particularly angina; may also particularly affect fetuses, sick, anemic and young children, affects nervous system impairing physical coordination, vision and judgements, creating nausea and headaches, reducing productivity and increasing personal discomfort.
Nitrogen Oxides	Increased susceptibility to infections, pulmonary diseases, impairment of lung function and eye, nose and throat irritations.
Sulphur Dioxide	Affects lung function adversely.
Particulate Matter	Fine particulate matter maybe toxic in itself or may carry toxic tray substance, and can alter the immune system. Fine particulates penetrate deep into the respiratory system irritating lung tissue and causing long-term disorders.
Lead	Impair liver and kidney, causes brain damage in children resulting in lower I.Q., hyperactivity

	and reduced ability to concentrate.
Benzene	Both toxic and carcinogenic. Excessive incidents of leukemia in high exposure areas.
Hydrocarbons	Potential to cause cancer.

Table 1. Pollutant v/s Effect on Human Health [1]

Out of all these pollutants, the major ones effecting human health adversely is Carbon Monoxide and Particulate Matter [2]. It is difficult for government officials to regularly advice vehicle users to inspect their vehicles in order to keep track of the air pollution caused by their vehicles. The government also finds it difficult to continue to compel vehicle users to regularly inspect their vehicles. In addition, these tests are very time consuming and costly. So, the vehicle user finds it to be a very busy and time-consuming task to check the vehicular emissions [3]. To overcome these kind of issues, IoT devices can be used to keep a check on the vehicular emissions. In the papers proposed by Siva Shankar Chandrasekaran [4], G. Arun Francis [5], Joseph Mathew[6], Subarna Shakya [7] and Akey Sungheetha [8], we can observe how these IoT devices can be implemented in order to detect the vehicular emissions using microcontroller like Arduino and semiconductor gas sensor. Also, in the work proposed by Arun et al. [9] the data is not being uploaded to the server and not converting the sensor data into standard ppm values. Our proposed work is unique, as it aims at designing a technical instrument, which can analyze the vehicular emissions in the standard ppm values and store that data in the IoT analytics cloud platform, i.e., ThingSpeak platform. Hence, the emission data can be easily accessible. Also, the respective Regional Transport Office (RTO) or Central Pollution Control Board (CPCB) can be notified immediately via an SMS alert.

III. PROPOSED SYSTEM : IOT BASED VEHICULAR EMISSION MONITORING SYSTEM

The most polluting substances from vehicles are Carbon Monoxide and Particulate Matter which can be detected with the help of semiconductor gas sensors [10]. The emissions from vehicles is completely unavoidable but, of course, controllable. With the development of semiconductor sensors for various gases, this paper aims to use these sensors in the vehicles by detecting the level of pollutants and indicate this level in ppm.

The overall execution of the prototype designed follows these steps:

Step 1: Detection of emissions
The gas sensor when placed near the exhaust pipe of the vehicle receives discharge from the exhaust pipe.

Step 2: Analysis of emissions
The analysis of the emissions is carried out using the ESP8266 microcontroller (Wi-Fi module). The detected or captured emission values are stored in the ESP8266 microcontroller (Wi-Fi module), i.e., the NodeMCU and the stored value is compared with the emissions limit value or the threshold value.

Step 3: ThingSpeak IoT analytics cloud platform
The measured emissions values are converted into real-time graphical data in units of parts per million (ppm). For instance, 1 mg/km = 1 ppm.

Step 4: SMS alert message
If the estimated release values exceed the given limit, an SMS warning message regarding excessive emissions is sent to the relevant authorities using a GSM module. The message includes the emission values and vehicle details.

Step 5: Display of data
The details of the measured emission values are displayed at the user-end, on a 16x2 LCD screen.

The following figure (Fig. 1) represents block diagram of the proposed prototype and various interconnections between the components used.

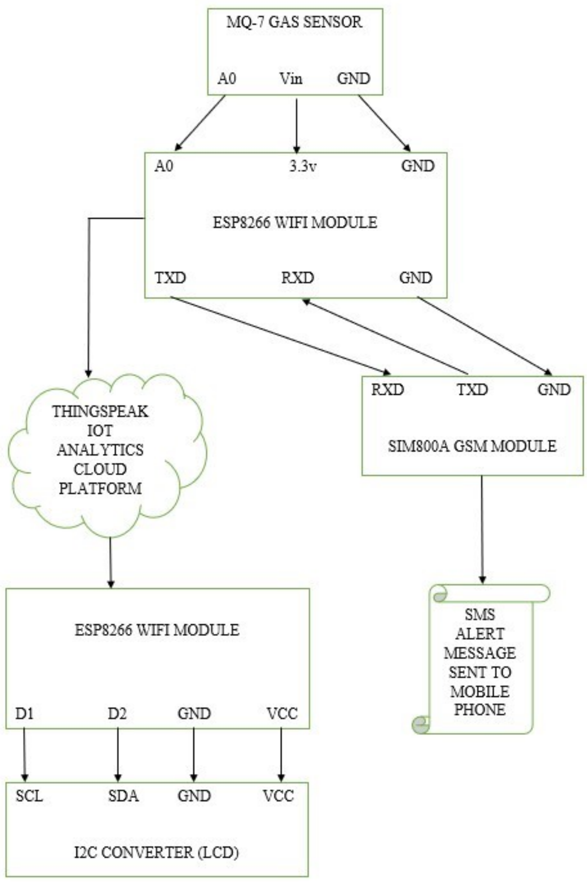


Fig 1. Block diagram of the prototype

IV. DESIGN AND IMPLEMENTATION OF THE IOT PROTOTYPE

A. Design Considerations

1. Cost: The overall cost of the prototype is estimated to be within Rs. 3000/- (~50 USD) . Hence, it is a very low-cost prototype.

2. Size: Compact and light-weight. It is easily mountable on the vehicle due to its compact size.

3. Power Supply: Energy consumption is low. ESP8266 microcontroller (Wi-Fi module) requires 9V battery and 3.5V to 5V adaptor for GSM module.

4. User-Interface (UI): ThingSpeak IoT analytics cloud platform provides real-time data in graphical form. Also, an LCD screen, which displays the obtained real-time data in ppm is provided at the user-end.

5. Network coverage: The range of the network is large. Since the data is uploaded to the server (ThingSpeak IoT analytics cloud platform), it can be accessed from any part of the world.

B. Design Goals

Through our extensive literature research, we were able to draw a number of conclusions as follows:

1. Carbon Monoxide (CO) and Smoke (Particulate Matter) are the main pollutants among various automobile emissions [11].

2. Even though there is vast availability of different types of emission detectors, very few of them tend to concentrate on the detection and analysis of the harmful vehicular emission components, such as, CO and PM.

Our approach of employing the ESP8266 microcontroller (Wi-Fi module) instead of the Arduino board, is a road less travelled, and our literature survey adds up to the point of performing the detection and analysis of vehicular emissions in a complex way, but in a low-cost and simple manner. So, we provide the community with a simple and low-cost emission detection system to reduce the pollution caused by the transport sector. The following figure (Fig. 2) depicts the overall working mechanism of the prototype in the form of a flow cart.

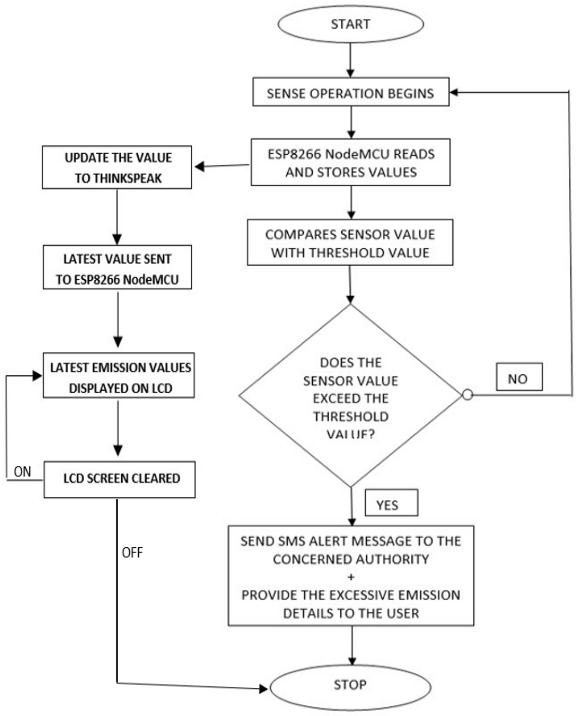


Fig 2. Flow chart of the prototype

C. Implementation

Firstly, in order to power up the prototype, we designed a single source power supply for the ESP8266 microcontroller (Wi-Fi module), which requires 5V power supply and for the SIM800A GSM module which requires around 10-12V power supply.

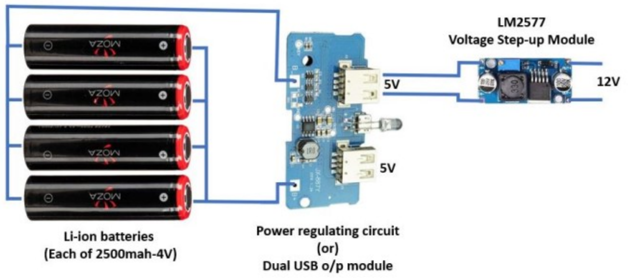


Fig 3. Single source power supply for the prototype

After designing the single source power supply as shown in the figure (Fig.3) , the required components were connected according to the block diagram mentioned in the previous section. The following figure (Fig.4) shows all the components with their connections according to the pin configurations shown in the block diagram (Fig. 1). Here, we have used two ESP8266 microcontrollers. One, in order to receive the gas emission values from the MQ-7 gas sensor and convert that analog data into digital form. The second Wi-Fi module is used to extract the latest CO and Smoke (PM) emission values from the ThingSpeak platform and display the same on the LCD screen. Both of them are independent of each other.

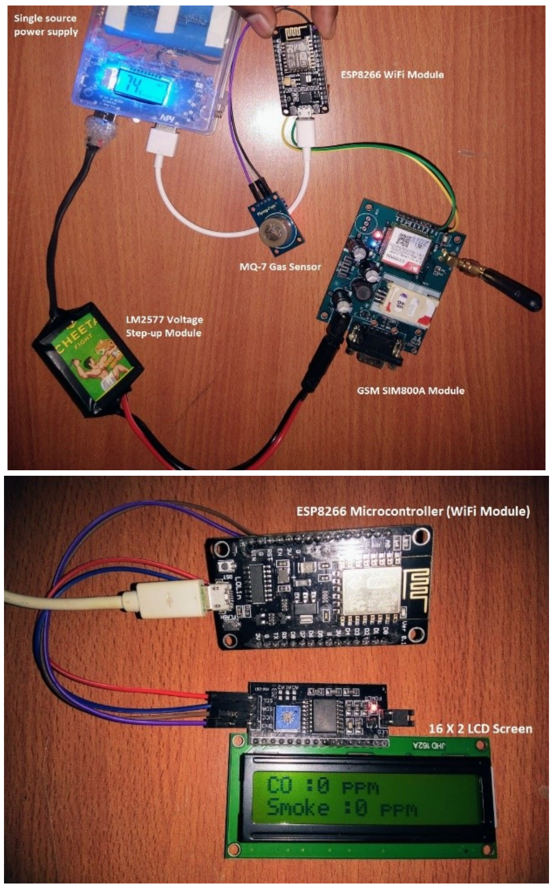


Fig 4. Prototype Implementation

Then, the entire prototype is designed in the shape of a box, which can be easily mounted at the exhaust pipes of the vehicles. This feature is helpful for analysing the vehicular emissions efficiently. The below figure (Fig 5.) shows the final design of our proposed prototype.

Fig 5. Final design of the prototype

V. TESTING OF MQ-7 GAS SENSOR AND SIM800A GSM MODULE

A. MQ-7 Gas Sensor

We can check if the sensor is working or not by just powering it up with 5V supply pin and have a current or resistance reading at the output pin. If there is a current or resistance reading, then the sensor is fine.

B. SIM800A GSM Module Testing

The GSM module is paired to the serial port of the COM port of the computer using the RS232 cable. The following commands (Table 2) are entered in the serial monitor and the respective acknowledgements are received from the GSM module [12].

Serial Monitor (Input)	Acknowledgement from GSM
AT Press ENTER	OK
AT+CREG? Press ENTER	+CREG:0,1
AT+CMGF=1 Press ENTER	OK
AT+CMGS=9148090555 Press ENTER	>
Type the Message Press CTRL+Z	OK

Table 2. GSM module testing commands

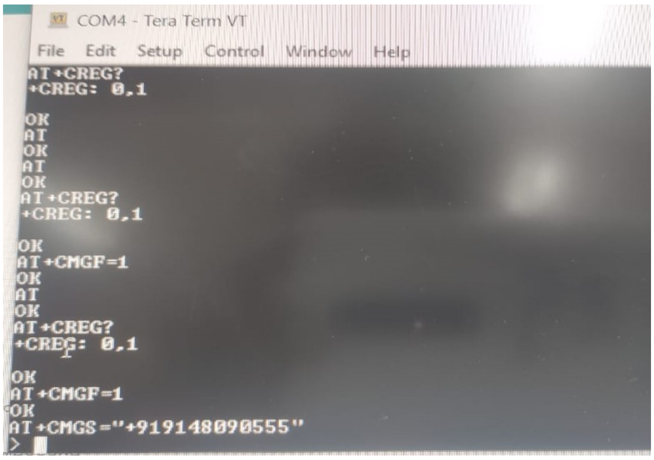


Fig 6. Software testing of GSM module

The above figure (Fig.6) shows the execution of the GSM commands and their respective responses. This step helps us to understand the connection status and the working condition of the SIM800A GSM module.

VI. RESULTS AND VERIFICATIONS

A. Results

The results were implemented in real time. The final prototype was exposed to a practical environment, i.e., vehicular emissions. The output of the device was observed on the serial monitor of the Arduino IDE platform. The following images (Fig 7.a and Fig 7.b) depict some of the results obtained from the prototype.

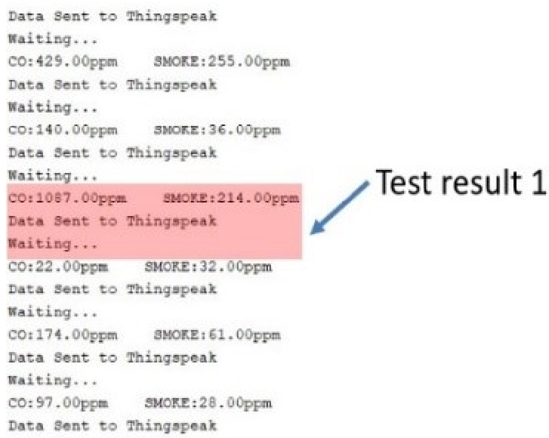


Fig 7.a Results (Test result 1)

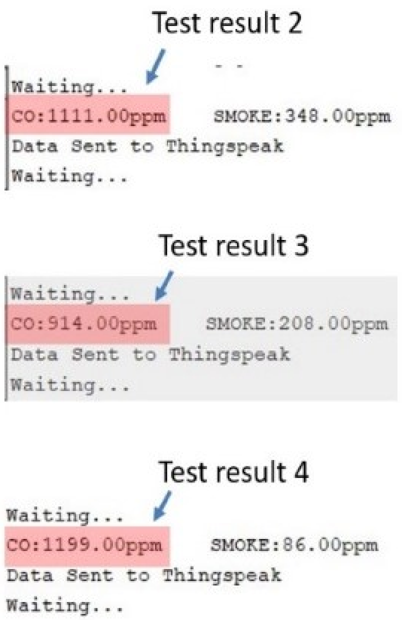


Fig 7.b Results (Test result 2, 3 and 4)

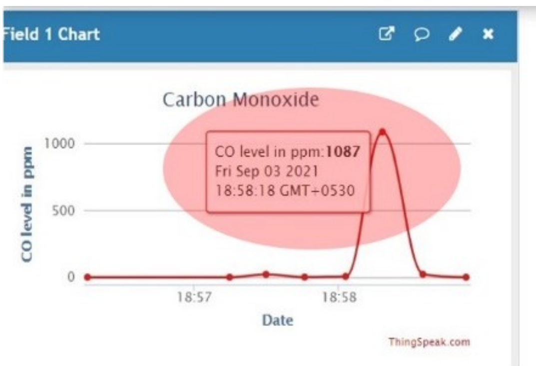


Fig 8. ThingSpeak platform

The above image (Fig.8) shows successful transmission of the vehicular emission data onto the ThingSpeak platform. We can also observe that this data is represented in real time graphical format.

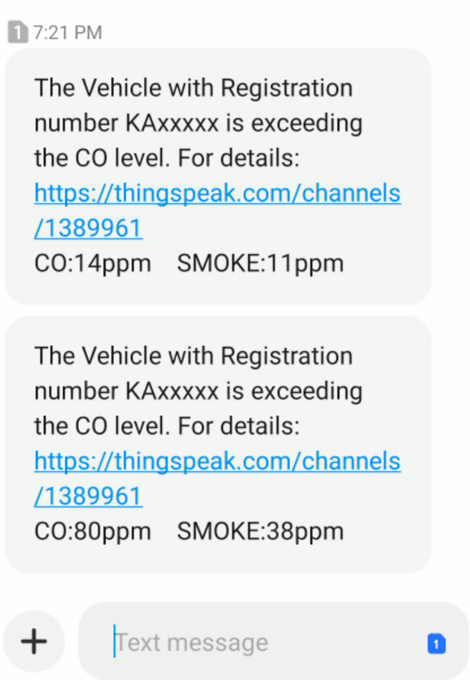
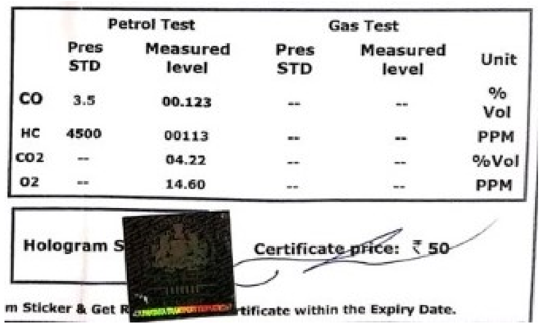


Fig 9. Message received at the desired mobile via GSM module

The above image (Fig. 9) is of the SMS received at the desired user end, when the Carbon Monoxide (CO) and Smoke (PM) levels exceed the threshold values. The SMS contains the Carbon Monoxide (CO) and Smoke (PM) values in ppm and the link to the ThingSpeak platform for further details.

B. Verification

The below figure (Fig.10) is the Emission Certificate (EC) received from the authorized vehicle emission test center. Here, we can observe that the standard emission limit of CO is 3.5 % by volume, i.e., 3500 ppm.



	Petrol Test		Gas Test		
	Pres STD	Measured level	Pres STD	Measured level	Unit
CO	3.5	00.123	--	--	% Vol
HC	4500	00113	--	--	PPM
CO2	--	04.22	--	--	%Vol
O2	--	14.60	--	--	PPM

Fig 10. Emission Certificate

The following table (Table.3) indicates the verification of the results obtained by the prototype designed. As mentioned by the government/ regulatory authority in the Emission Certificate, the value of Carbon Monoxide (CO) is 0.123% by volume, i.e., 1230 ppm. The series of results obtained by the prototype averaged to 1077.75, resulting a deviation of 10-12% from the desired value.

Sr. No	Test value (in ppm)	Expected output (in ppm)	Error (in %)
1	1087	1230	11.60%
2	1111	1230	9.67%
3	914	1230	21.61%
4	1199	1230	2.50%
Average	**1077.75**	**1230**	**12.37%**

Table 3. Verification table

VII. CONCLUSION

Pollution identification and analysis system works in conjunction with the current traffic to electric vehicles and hybrid systems to avoid emissions of harmful gases into the atmosphere. The MQ-7 gas sensor is placed at the region where the emissions are present or being emitted. The senor sends the analog signals to the ESP8266 microcontroller. At the microcontroller, the analog signals are converted into digital values.

Later, these digital values are converted into parts per million (ppm) using the logarithmic graphs available in the datasheets of the MQ-7 gas sensor. The ppm values of Carbon Monoxide (CO) and Smoke (PM) are uploaded to ThingSpeak platform in real-time basis. From this platform i.e., the server, the latest updated values are sent to another ESP8266 microcontroller via Wi-Fi, which is in turn displayed at the user end on an LCD screen.

Simultaneously, these ppm values are compared with the standard limit values provided by the government. If the Carbon Monoxide (CO) and the Smoke (PM) levels exceed the limit, the respective concerned authority can be notified through an SMS alert.

Input:

- Single source power supply for both the ESP8266 microcontroller and the GSM module.
- MQ-7 gas sensor.

Output:

- The emission values are displayed on an LCD screen.
- If the limit value is exceeded, the result is communicated via the GSM module.

Features:

- *Reliability* - In order to make our prototype cent percent reliable, it is necessary that we eliminate the probe of doubt about the output data obtained. The output data is obtained through real-time analysis of the vehicular emissions.
- *Availability* – The product can be made available to all the concerned individuals.
- *Efficiency* - The product is efficient in real-time with minimal delay allowance in data flow between the user and the system. Also, it is cost effective.

In the future, Global Positioning System (GPS) technology can be implemented into this prototype to send positional information to the concerned authority and to calculate the amount of emissions emitted from vehicles in a particular region.

A Secure Digital (SD) Card module feature can be implemented into this prototype to store the data into a hard-drive in case of loss of connectivity. It is also important to consider the other emission restrictions and revitalize the system to be equipped with the latest emission levels to meet the emission regulations. The system can also suggest nearby authorized service stations to the user for immediate servicing.

VIII. REFERENCES

[1] Dr. Jayadev Sahu, Sai Ram C.V, Kalpana Sharma, Anita Khanna, 2018. Vehicular Pollution in India. *Lok Sabha Secretariat, Government of India.*

[2] Chetana Khandar, Sharda Kosankar, 2014. A review of vehicular pollution in urban India and its effects on human health. *Journal of Advanced Laboratory Research in Biology*, pp. 54-61.

[3] Sneha S. Kamalakar, Mousami S. Vanjale, 2017. Notifying and Inspecting Vehicle emission and Temperature of vehicle engine. *IEEE Conference on Emerging Devices and Smart Systems (ICEDSS 2017).*

[4] Siva Shankar Chandrasekaran, Sudharshan Muthukumar, Sabeshkumar Rajendran, 2013. Automated Control System for Air Pollution Detection in Vehicles. *International Conference on Intelligent Systems, Modelling and Simulation.*

[5] G. Arun Francis, M. Dhinesh, J. Arok Lijo, 2019. IoT Based Vehicle Emission Monitoring System. *International Journal of Innovative Technology and Exploring Engineering (IJITEE).*

[6] Joseph Mathew, Shancy Elizabeth Shaji, Vandana H, 2019. Vehicular Pollution Monitoring System Using IoT. *Journal of Communication Engineering and Its Innovations,* pp. 33-39.

[7] Shakya, S. (2021). A Self-Monitoring and Analyzing System for Solar Power Station using IoT and Data Mining Algorithms. Journal of Soft Computing Paradigm, 3(2), 96-109. doi:10.36548/jscp.2021.2.004

[8] Sungheetha, Akey, and Rajesh Sharma. "Real Time Monitoring and Fire Detection using Internet of Things and Cloud based Drones" Journal of Soft Computing Paradigm (JSCP) 2, no. 03 (2020): 168-174.

[9] P. A. M. Devan, F. A. Hussin, R. Ibrahim, K. Bingi and M. Nagarajapandian, "IoT Based Vehicle Emission Monitoring and Alerting System," *2019 IEEE Student Conference on Research and Development (SCOReD)*, 2019, pp. 161-165, doi: 10.1109/SCORED.2019.8896289.

[10] M. Rathod, R. Gite, A. Pawar, S. Singh and P. Kelkar, "An air pollutant vehicle tracker system using gas sensor and GPS," *2017 International conference of Electronics, Communication and Aerospace Technology (ICECA)*, 2017, pp. 494-498, doi: 10.1109/ICECA.2017.8203734.

[11] Bolaji, Bukola & Adejuyigbe, S.B.. (2006). Vehicle Emissions and their Effects on the Natural Environment - a Review. Journal of the Ghana Institution of Engineers. 4. 35-41.

[12] Abdul Rahman, Nur & Ibrahim, Noor & Lombigit, Lojius & Azman, Azraf & Jaafar, Zainudin & Abdullah, Nor & Mohamad, Glam. (2018). GSM module for wireless radiation monitoring system via SMS. IOP

Conference Series: Materials Science and Engineering. 298. 012040. 10.1088/1757-899X/298/1/012040.