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IoT Based Vehicle Emission Monitoring and Alerting System

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Abstract— **This study was carried out to analyze the variations of hazardous pollutants like Carbon Monoxide (CO), Carbon Oxides (COx) and Nitrogen Oxides (NOx) in Tamil Nadu. The major source of air pollution in urban areas mainly in developing countries like India is due to the transportation sector. Road and Transportation Office (RTO) and Central Pollution Control Board (CPCB) are the monitoring authorities of the emission standards. This paper measures the emissions standards in a real-time process using various sensors namely smoke sensor which is placed at the exhaust of the vehicle. The data collected verifies the standard limits and provides information to the vehicle operator, RTO, and CPCB through the Global System for Mobile Communication (GSM) and the Internet of Things (IoT) for further analysis. The Indian government provides the Fitness Certificate (FC) for every vehicle by monitoring its behaviour. The control strategy coding for calculating the emitted gas limits has been done in PIC Microcontroller which analyzes the data and yields the statistics which are then compared with the standard values. Drivers and nearby control stations are provided with continuous feedback and warnings if the limits are exceeded. The Gas sensor is installed in the proposed control system by indicating the values provided in the Liquid Crystal Display (LCD).**

Keywords: IoT, PIC controller, Gas Sensor, Vehicle Emission, GSM.

I. INTRODUCTION

The high level of air-pollution in urban areas, caused in no small extent by road transport, requires the implementation of continuous and accurate monitoring techniques if emissions are to be minimized. 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].

The Air (Prevention and Control of Pollution) Act was enacted in 1981 and amended in 1987 to provide for the prevention, control and abatement of air pollution in India. 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. The new air quality standards in India to safeguard the society are tabulated in Table 1 [3]. Taxi, buses, and trucks are responsible for 72% of CO and NOx release in the metro cities. Due to these alarming conditions CPCB made FC renewal mandatory every year for Heavy Transport Vehicles (HTVs) and five 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. 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 units, 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 in 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 [5]. This paper focuses on the development of field instruments as a solution to spread attentiveness in each and every individual. The presented prototype in this paper 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.

The rest of the paper is organized as follows: Section II is dedicated to the related works on emission monitoring systems. The proposed system is presented in Section III. The results and discussions are given in Section IV followed by conclusion in Section V.

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TABLE I
EMISSION STANDARDS IN INDIA

Year	Norms	CO (g/km)			HC+ NOx (g/km)		PM (g/kwhr)	Diesel Vehicles	
		Passenger cars	Diesel vehicles	2/3 wheeler	Passenger cars	2/3 wheeler	Diesel vehicles	HC (g/kmhr)	NOx (g/kmhr)
1991	-	14.3 - 27.1	14	12 - 30	2.0 (Only HC)	8-12 (only HC)	-	3.5	18
1996		8.68 - 12.40	11.2	4.5	3.00-4.36	3.6	-	2.4	14.4
1998		4.34 - 6.20	-	-	1.50-2.18	-	-	-	-
2000	India stage - 2000 norms	2.72	4.5	2.0	0.97	2.0	0.36	1.1	8.0
2008	BS - II	2.2	4.0	1.6	0.5	1.5	0.15	1.1	7.0
2010	BS - III	2.3	2.1	1.0	0.35	1.0	0.10	1.6	5.0
	BS - IV	1.0	1.5	-	0.18	-	0.02	0.96	3.5

II. RELATED WORKS

The increase in CO2 level is predominantly irreversible, even after the emission are eliminated for 1000 years. Among these irreversible impacts there is a reduction in rainfall and high heat waves leads to the formation of 'dust bowl' conditions in several regions over the century. The drastic growth in CO2 concentration caused the atmospheric temperature raise up to 3.2°C which generated thermal expansion of oceans causing the sea level to rise from 0.4 to 1.0 meters. Because of these harsh conditions, several places around the globe will face very less precipitation, high heat waves leading to the formation of 'dust bowl' conditions [6].

A vehicle monitoring system using on board IoT was successfully implemented to gather data from two different driving patterns specifically deceleration and speed according to slope of the road. It was found that the emission of CO2 was consistently lower in the vehicle whose engine oil was changed frequently compared to the other vehicle. The increase and decrease of CO2 discharge depends on the speed of the vehicle. Hence there is a good opportunity for identifying the CO2 emissions based on interval of changing the engine oil and the frequency are significantly provided [7]. To react to the climate change, United Nations Framework Convention on Climate Change (UNFCCC) conducts the global summit to make the developing and developed countries to cut down their emissions by minimum of 5% so that the global climate change will stay under 2°C, to avoid severe global climate change in forthcoming years. In reaction to this in 2015 Philippines announced in Intended Nationally Determined Contributions (INDC) to cut down their entire emissions in 2030 by reducing the utilization of fossil fuels for energy, transportation, industry, and domestic needs [8].

About 77% of emissions come from only 3 sectors namely energy, manufacturing and transportation in India given in Fig. 1, which is a huge amount contributing 1.14 tons per capita. These emissions are based on latest available Social Accounting Matrix (SAM) [9].Different kinds of road patterns majorly influence CO2 emissions because of irregular and sloppy roads. The effect of road grade has been evaluated on fuel consumption which compares the fuel economy. Due to this the emission levels is whooping approximately to 10% in case of elevated hilly roads and 2% on flat roads. From this condition it can be seen that, fuel consumption

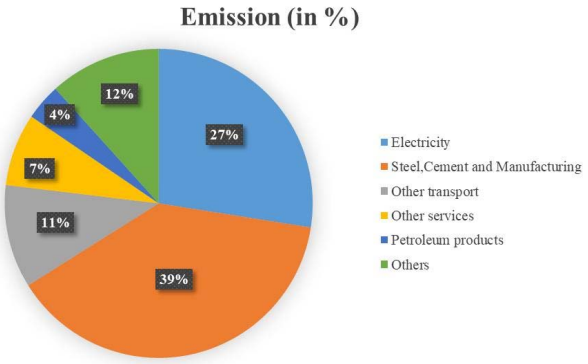

Fig. 1. CO2 Emissions by sectors

on flat route is averagely 15% to 20% higher than that of hilly routes[10] and [11]. Meanwhile, fuel consumption and emissions are compared using different driving patterns like sudden acceleration, sudden breaking and running the vehicle in idle condition which have a strong impact in emission. It has been estimated that fuel can be saved up to 19% for manual vehicles and 7% for an automatic ones [12].

As reported in [13], [14], [15] and [16] the transportation sector was the primary reason for the air pollution in various countries. For this problem, most of the countries deployed the Wireless Sensor Networks (WSNs) to know the most polluted roads and the areas to identify the different effective measures to reduce the suspended particulate matters, toxic gas emissions which are causing serious health concerns. Since a lot of sensors and data communication is involved to monitor the air quality, Khedo et al [11] uses WSN with a hierarchy routing protocol to gather the different motes data and identifies the duplicated data, distorted data, and noise data which is then it will aggregated to make simple data for processing and identifying the air quality. This protocol also helps the motes to sleep during the idle condition.

In the city of London [13] the government uses Mobile Discovery Net (MoDisNet) to monitor and get the real-time data from the various mobile and fixed sensor stations to analyze the AQI in the city. Since it has a mobile sensor unit it utilizes GUSTO sensor technology to identify the surrounded pollutants on the roads, these data will be sent to the station where data mining will happen for analysis and it will result in the formation of pollution data map indicating

with various ranges of pollutants in certain colour patterns.

III. PROPOSED SYSTEM

From prior discussions, it is clearly known that transportation is one of the major factors for climate change and many adverse effects in all the living creatures. Most of the existing system employs WSN to get the data from the motes which consist of high range noise, delay and duplicated signal. Hence the processing and getting the real-time data makes this as a time-consuming process [14].These methods are applicable to gather only the average air quality rather than identifying the individual polluting vehicles. While going for the deployment and cost wise, the existing methods involves more protocol hierarchy algorithms to filter out the noise and duplicated signals resulting in more complex nature [13]. For avoiding the same this paper has aimed to reduce the complex nature of getting the data and low-cost monitoring setup was suggested.

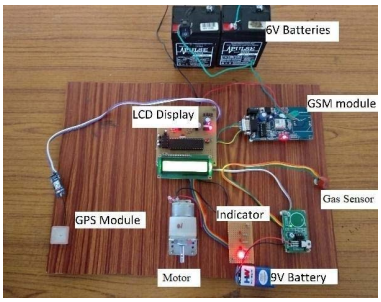

Fig. 2. Working prototype of the system

The proposed methodology focuses in identifying and monitoring the individual vehicle emission level as well as alerting the CPCB and RTO if the vehicle exceeds the standard limit (See Table I). This method consists of a gas sensor capable of detecting the combination of both CO and COx, which was placed on the exhaust of the vehicle. The sensor is also protected from heat dissipation by placing it in the GALV Thermal Isolation Clip from the vehicle exhaust which causes the sensor to malfunction. The system is equipped with the GPS to send the location to the officials to detect the polluted vehicle. The prototype consist of dual 6V batteries which supplies power to the whole setup including GSM, LCD Display, Global Positioning System (GPS) module and indicator, except the gas sensor since it uses a single 9V battery separately due to its excess power consumption. The collected data is stored in PIC micro controller in a real-time basis and is evaluated using embedded C coding. Any abnormality in the comparison is communicated to the driver through LCD display and to the nearest control station via GSM and GPS modules. The

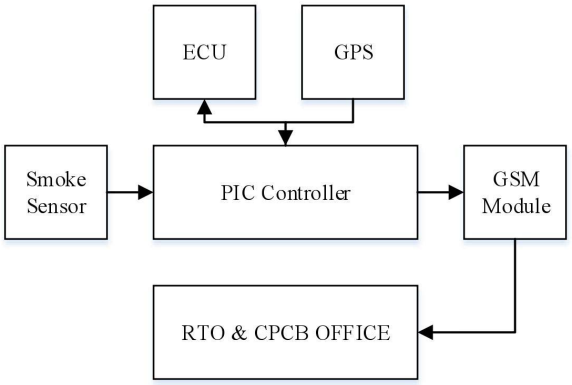

Fig. 3. Block diagram of the proposed system

overall working prototype is shown in Fig. 2. Furthermore, the block diagram of the proposed system is shown in Fig. 3.

IV. RESULTS AND DISCUSSIONS

The data collected from the gas sensor is processed and the irregular emission is detected which is then registered to RTO and CPCB for further actions.The system working flow diagram is shown in Fig. 4. The Engine Control Unit (ECU) is connected to the PIC controller which detects the excess emission and reacts by turning off the vehicle. This will be done by cutting down the electrical connection going to the spark plug, for the same the warning to the user is shown in Fig. 5 the driver is provided with maximum of 200 seconds for parking the vehicle in a safer lane which can also be noticed in Fig. 5 and the part of pseudo-code for this specific condition is given below.

```
if(VAL5==1){
VAL5=0;
gsm_command
(TN 35 AZ2351 CO LEVEL
"ABNORMAL" );}
delay(200);
for (j=16;j<28;j++)
    {
    send=(gpsdata[j]);
    TXREG=(ser);
    delay(200);
    }
lcd_data(m+0x30);
lcd_data(k+0x30);
lcd_init();
gsm_init();
```

Meanwhile, the system interfaced with the vehicle at normal condition is shown in Fig. 6 which continuously senses the gas from the exhaust. The time period remains at zero value while the vehicle is running in usual condition. The abnormal condition detected in the vehicle is sent to

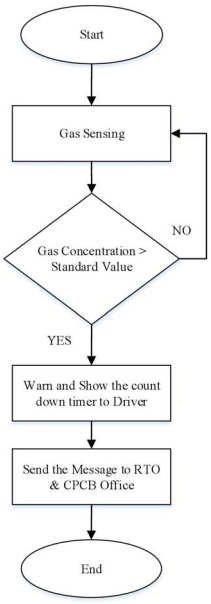

Fig. 4. Flow diagram of the proposed system

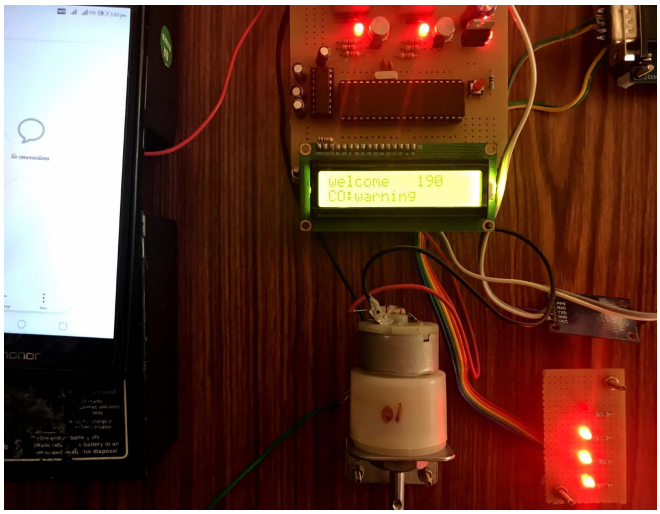

Fig. 5. Vehicle warning status due to exceeding the limit

the RTO and CPCB office and they issue the summon and tow the vehicle to the nearby station using GPS location shown in Fig. 7. The message which is sent contains the abnormal emission level with GPS location coordinates. The FC expiry of the vehicle is one of the most important reason to prevent exhaustive emissions. Hence the proposed system has special commands for sending alert message to RTO if the FC expires which can be seen in Fig. 8 and the pseudo-code for this specific condition is given below.

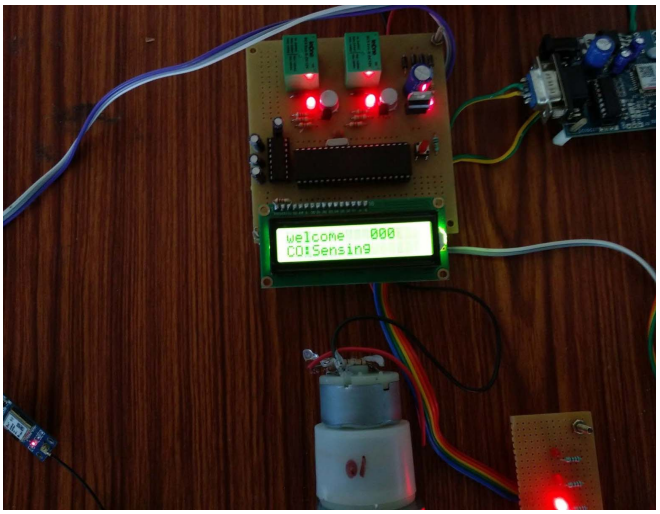

Fig. 6. Gas sensing at normal condition

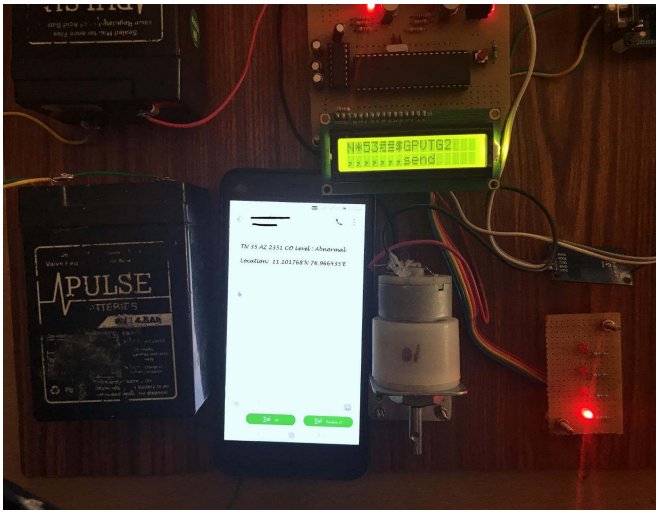

Fig. 7. Message received at the RTO office and location of the vehicle

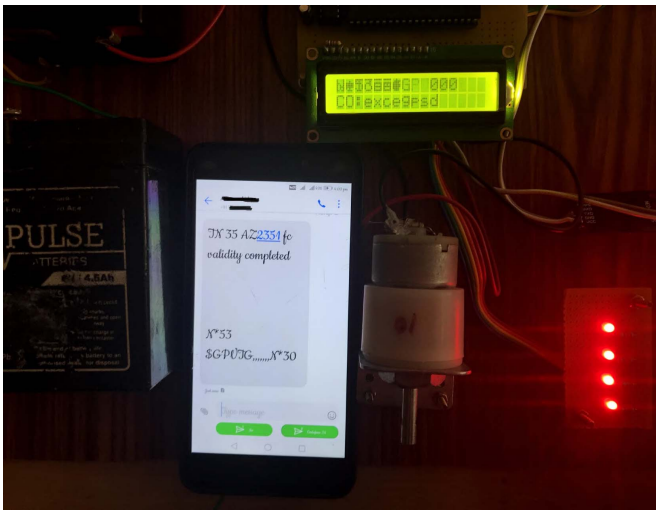

Fig. 8. Message received at the RTO office due to the expiry of FC

```
void gps_send()
{
lcd_command(0xc7);
delay(200);
lcd_display("gps",4);
lcd_init();
lcd_data(m+0x30);
lcd_data(k+0x30);}
gsm_init();
gsm_command
(TN 35 AZ2351 fc
validity completed);
}
```

Realtime data taken from the CO2 sensor is given in the Table II below for various conditions.

TABLE II

CO2 CONCENTRATION MEASURED VALUE AND STANDARD VALUE

Condition	Standard Value (g/km)	Sensor Value (Measured Value) (g/km)
Normal	$\leqslant$1.0	0.8
Abnormal	$\geqslant$1.0	1.2 - 1.8

V. CONCLUSION

Each country follows different emission standards based on their geographical location and availability of resources but most of them try to implement the UNFCCC summit standards in order to reduce the emission and conserve the environment. The proposed prototype in this paper is implemented in the society which is very cost effective and consumes much lesser space along based on the existing standards. But by once drawback condition occurs when the vehicle is travelling in the elevated hilly regions. On these regions the standardised emission values will tends to vary due to the need of high pulling torque. On these circumstances with the permission from the government the process for overriding the automatic controller takeover maybe avoided to reduce the accident happening situations.

In the future, it is also important to consider the other gas parameters and to update the system to equip with the new gas emissions regulations standards. The system could also suggest the nearby authorized service stations to the user for immediate servicing. The proposed automated emission monitoring system works in parallel with the current move towards electric vehicles and hybrid systems to avoid the emission of harmful gases into the atmosphere. The government rules for the identification of expired and summoned vehicles has to be followed strictly in order to maintain the vehicle properly.

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