

COST EFFECTIVE AUTOMATED AIR POLLUTION CONTROL FOR VEHICLES

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Abstract: *With improvement of civilization, vehicles have become a part and parcel of everyday life. Geographical locations, unavailability of commodities and essential services, requirement of time management in fast paced urban life has proved the necessity of using fossil fuel driven vehicles. One of the adverse effects of using vehicle in a non-scientific and uncontrolled way is air pollution. Uncontrolled utilization of fossil fuel is caused due to incomplete combustion of fuel. Although quality of fuel and engines is upgrading day by day, but negligence of proper maintenance of vehicles by owners is also increasing. This paper aims at creating a small low cost prototype that not only alarm the user about the over pollution level but also compels to take necessary action before using the vehicle.*

Key words: *Automated pollution control, air pollution control, environment protection, smoke sensor.*

1. INTRODUCTION

Air is a mixture of different types of gases e.g. oxygen, hydrogen, nitrogen and several types of chemical oxides present in the environment. Air pollution refers to the emission of different types of particles (especially solid suspended particles), dangerous for the health of all kinds of living species like human on earth. The reasons of pollution specially include gaseous chemicals emitted from Car, factories, dust, pollen and mold spores which may be suspended as particles in air. Ozone gas is one of the major components of air pollution in cities and such pollution created by ozone is called smog. These pollutants increase the chance of several unrecoverable diseases in heart and lung, especially in children when inhaled [1].

In developing countries like India [2], use of fossil fuel e.g. wood or coal for domestic purpose in villages expose people to polluted air at house hold purposes. It is also to be noted that three billion people around the world are using the above sources of energy for their daily heating and cooking needs [3]. In developing countries, housewives are vulnerable to highest risk for lung disease due to their longer duration of exposure to indoor air pollution [4]. Extreme air pollution is recorded in not only in urban but also in rural areas of India, due to the fast industrialization, Nevertheless, biomass combustion practices for house hold needs originates a major source of household air pollution in India and in Nepal (5, 6). The pollution profile apart from villages, not only just caused by the industrialization but passively it has occurred due to the unethical activities of human greed and negligence to environment. Uncontrolled growth of industry cost deforestation. Good transportation facilities and fast pace of life has made people ignorant to their moral duties of checking standard pollution level of their private vehicle for the benefit of society and the environment. Government has imposed several laws and punishment for violation of those recommended standards but people are especially interested to the escape clauses of Law rather than obey their duties. Hence, in this paper, an attempt has been made to create a prototype that automatically aware the vehicle owner about the pollution status of private vehicle and continuously produces alarming sound until step is taken to minimize the pollution level from the vehicle below the standard value.

2. LITERATURE REVIEW

In this section, literature on air pollution and the innovative remedies narrated by different researchers has been mentioned. Srivastava, R.K., et.al. (2013) [7], reviewed the condition of Indian traffic system which revealed that around 70% of the air pollution is contributed from vehicles. Extremely high level of CO (Carbon Monoxide), SO₂ (Sulphur Di-Oxide), NO₂ (Nitrogen Di-Oxide), and other suspended particles in air was observed by them. In their research work, it has been found that CO was producing the highest 90% emission from the total emission. It has been also studied that within 7 years of time period, Number of vehicles has been increased by double and 72% of increase in the two stroke two wheelers. The estimation of emission from different vehicles depends on number of vehicles on road and distance travelled by them in a year and it has to be estimated per vehicle as shown in table 1.

Table 1 Emission from different vehicles of India

Categories	CO ₂	CO	NO _x	SO ₂	PM	HC
Bus	24748.16	207.26	679.73	79.24	31.36	51.72
Omni Bus	8508.42	60.94	200.53	23.45	9.28	15.11
2-wheeler	8701.08	719.64	62.15	4.25	16.36	464.49
LVM(passenger)	4378.10	370.29	92.93	2.11	14.52	10.16
LVM (goods)	44654.58	442.04	110.94	123.02	17.33	12.13
Cars & Jeep	23901.22	212.30	22.14	5.67	3.22	38.01
Taxi	2367.80	10.23	5.68	117.05	0.80	1.48
Others	5705.22	57.41	64.54	32.19	3.98	8.96

Table 1: Source : CPCB website; courtesy : Shrivastava RK, Neeta S, Geeta G. Air pollution due to road transportation in India: A review on assessment and reduction strategies. Journal of environmental research and development. 2013 Jul 1;8(1):69.

In Table 2 it clearly indicates the amount of pollution in various cities and it has been seen that among all the constituent pollutants, CO has the most influence on the health issues due to pollution. In view of this tables, several measures had been taken by the Govt. of India. For petrol and diesel vehicles various chemical measures have been taken to reduce hydrocarbons and CO emission. But NO_x and particulate matter could not be controlled. Fuel quality has been improved by reducing sulphur content below 50ppm, use of lead free gasoline, biodiesel, and natural gas and as specified by Bureau of India standards (BIS) to maintain carbon content as low as possible in the emitted pollutant. It has been found that periodical inspection and maintenance of vehicles can be taken as the key factor that can reduce the pollution by 30%-40%. Moreover, upgrading public transport system by efficient traffic routing and less use of personal vehicles, improved engine quality, better fuel quality can reduce the graph of pollution in India.

Table 2 Estimated pollution load in Indian Cities

City	Pollution Load in metric tons per day			
	CO	NO _x	HC	PM
Delhi	421.84	110.45	184.37	12.77
Mumbai	189.55	46.37	89.93	10.58
Kolkata	137.50	54.09	47.63	10.80
Chennai	177.00	27.30	952.64	7.29
Bangalore	207.04	29.72	117.37	8.11
Hyderabad	163.95	36.89	90.09	8.00
Kanpur	28.73	7.25	11.70	1.91
Agra	17.93	3.30	10.28	0.91

Table 2 : source: Auto Fuel Policy report, courtesy : Shrivastava RK, Neeta S, Geeta G. Air pollution due to road transportation in India: A review on assessment and reduction strategies. Journal of environmental research and development. 2013 Jul 1;8(1):69

But, because of the negligence to the moral duties, users forget to keep proper maintenance profile of the used vehicles. The result is increased air pollution. Hence researchers have attempted to find solution to the negligence of user and inform them to take necessary measures regarding maintenance. S. S. Chandrasekaran et.al (2013) [8], in their research paper have proposed a method that not only informs about pollution level when the threshold level is crossed but also searches nearby service centre through included GPS system. Also, this system cuts the fuel supply of engine when vehicle is not serviced after a specific time period is over. This method is very much capable to reduce pollution by forcing the vehicle to become inactive after certain period of time, but at the same time it is costly due to use of GPS. Four wheelers have inbuilt GPS system today but most of the two wheelers don't have GPS and they are quite outnumbered on road. Making the vehicle inactive may psychologically make user annoyed and force him/her to completely remove the device from vehicle which can make a negative effect on pollution free environment.

C Joshi (2017) et.al, [9] have proposed a method that uses data logger connected to web server of motor vehicle department that charge suitable levie due to increase in the level of pollution. It although generates revenue to government but practically creating a large database of vehicles with such data logger connected to every vehicle is difficult to implement. The suitable network connectivity in rural areas is also another issue.

T. Pavan Kumar (2019) et.al.[10], have proposed another model which not only estimates the pollution emission level from vehicle but it also takes care of safety of the driver by using an alcohol level sensor. Basically this approach will give the permission of ignite the engine only if the level of alcohol consumed by the driver below a threshold level. The GSM module attached to the system will send the coordinates of location of the vehicle to the family members so that they can rescue the driver from getting accident. Even the engine will not start if the pollution level is above threshold level.

In this paper, the authors have tried to implement a possible improvement over the circuit cost, size and which not only aware people but also give them enough time to do maintenance of the vehicles. They will be also encouraged to take public transport to make the environment less polluted by not using individual private vehicles.

3. PROPOSED SYSTEM

In this paper, a new method has been followed which is not only small in size but also cost effective because it does not employ any network connection or GPS. It uses locally available low cost components and a small prototype board arduino Uno. Arduino uno has been chosen for its easy and open source programming interface, huge library support and rapid prototype development capability. MQ-135 gas sensor module is chosen for its capability to sense CO₂ (carbon di-oxide) which is considered to be one of the most influencing element to cause air pollution. Gas concentration of MQ-135 sensor is measured as per the Gironi's Formulation [11] for chosen gas. The formula used is given by:

$$y = ax^b \quad (1)$$

Where, y = gas concentration in ppm, x = resistance ratio (R_S/R_O), a = scaling factor and b = exponential factor. Here R_S is the sensing resistance which varies with gas concentration and R_O is the sensor resistance at a certain gas concentration. The values of scaling factor and exponential factor is obtained through specialized method depicted by Gironi's formula.

Variation of gas concentration varies the value of sensor resistance (R_S) which is measured in terms of output voltage at the analog input pin of arduino uno. As per the specific load resistance of the sensor (Here is $1K\Omega$), the value of sensor resistance for different gas concentration is given as:

$$R_S = \left(\frac{1023}{\text{Analog Value}} - 1 \right) R_L \quad (2)$$

Here, digital reading for maximum possible output voltage is 1023 because of 10 bit ADC at analog channel of arduino Uno, and Analog value is the actual digital reading corresponding to the gas concentration. Once we obtain the value from equation (2), we can obtain the value of gas concentration in ppm using equation (1).

The working of the system is depicted along with the system block diagram in the next subsections as follows:

3.1. *System block diagram-*

The following system represents the basic block diagram by which this prototype works. The functions of various blocks are given as follows:

- Sensor System: The sensor system is the heart of this prototype which is used to detect one of the most common poisonous gases from the emitted smoke of the engine. As a prototype, only one sensor has been used to detect a particular gas level from the engine. Here, MQ 135 gas sensor has been used to convert the gas density emitted from the vehicle into equivalent electrical signal.
- Controller: Here arduino Uno R3 development board has been used that contains analog channels to connect the gas sensors and digital ports to control the actuators associate with the prototype. The controller takes necessary decisions based on the pollution level.
- Circuit breaker: Circuit breaker is connected to the electronic ignition system. This is used to control the pollution from vehicles which emits pollution above a specific standard level. The circuit breaker plays an important role by not allowing the pollutant vehicles to start the engine. Although decision of making the vehicle completely inoperative is taken after a prolonged period of time which is not implemented in this prototype.
- Ignition system: Ignition system is the fundamental device to start the engine. When the start key is turned on by the rider, a small current is produced by the ignition circuit that flows through the circuit breaker and the magnetic field produced by the current flowing

through the coil, helps to ignite the engine. By using the circuit breaker, the ignition system is deactivated.

- **Timer:** - A software timer has been implemented in the prototype that counts the interval to ring the alarm periodically if pollutant gas is present above acceptable level from standard value. This timer will produce a periodic alarm for one hour in two minutes if no preventive measure is taken. After one hour the buzzer will continuously ring until pollution preventive action is taken.
- **Alarm:-** A single buzzer is used to provide an alarm signal. It is connected through a single channel relay which is again connected to digital output pin from arduino uno.

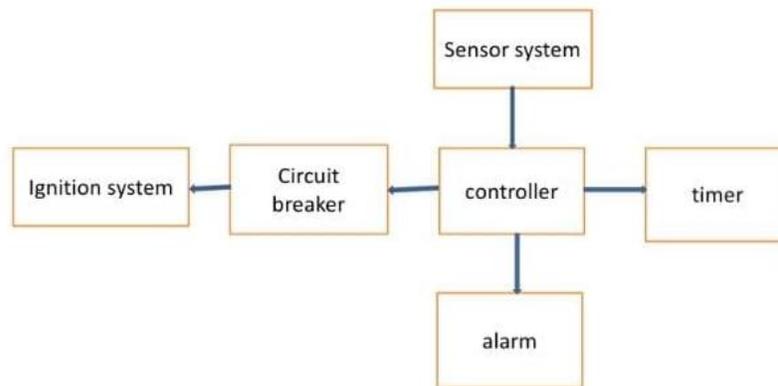


Figure 1: Block diagram of the proposed model

3.2. Proposed Algorithm -.

- The proposed model of vehicle pollution detection and control runs on the following algorithm. The steps of detection are shown below:
 - Step 1: To detect the pollution emitted by the vehicle, owner need to start the engine.
 - Step 2: After the engine starts, gas density of the particular gas in terms of voltage is produced by the sensor and sent to controller.
 - Step 3: The controller compares the data received by sensor with the standard data of pollution at the place and produces a high or low output on digital port
 - Step 4: If the output produced from the comparison is high, a buzzer rings in the system for every two minutes for next hour to remind the owner about the status.
 - Step 6: If the specified 1 hour time is over, the siren will continuously ring until the engine stops

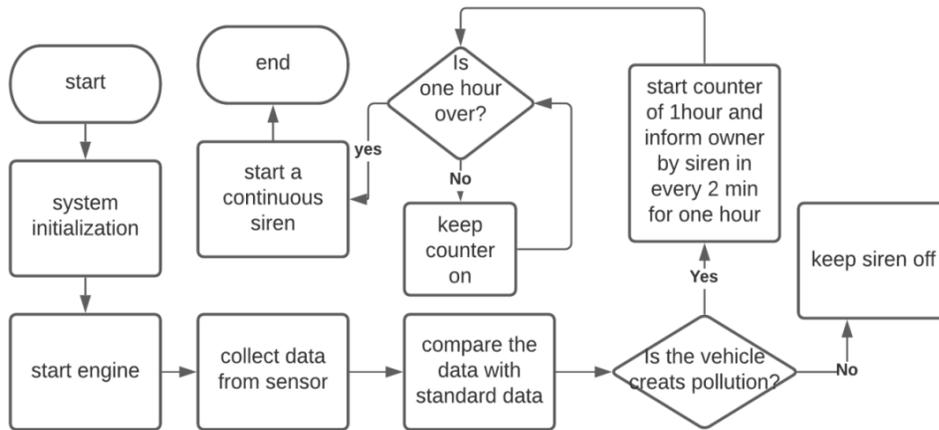


Figure 2: Flowchart of the proposed algorithm

4. RESULT AND DISCUSSION

In this prototype, the system function has been tested with some different types of gas concentration apart from direct exposure to the vehicle exhaust. It is because, the outcome that we obtain in ppm from the exhaust need to be converted into standard gram/kilometer which requires the device to be connected and get the data for some kilometers run. In this paper, the prototype has been tested with gas emission from known house hold components like match stick, incense stick and mosquito repelled stick. It has been found that the system works as per the flow diagram and is able to produce alarm when a gas concentration exceeds threshold gas concentration. Fig 3 below shows the prototype of the designed system



Fig.3 working prototype

5. CONCLUSION

The system prototype shown over here is low cost and can work properly. But this system needs much more conversion coefficients to become usable in real scenario like estimation of

pollution in ppm from vehicle. The vehicle used in India has different fuel categories like diesel gasoline as well as natural gas which need different standards. Also the pollution is measured in terms of gram/kilometre which again need to be converted into ppm. These are some future scope in finding the real conversion factor to get the vehicle pollution level into standard ppm values. In near future the device could be connected through internet to the motor vehicle department to inform about the owner of the vehicle not obeying the standards of pollution. Also the upgradation in the standard could be automatically updated in the device through IoT.

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