

# Cloud and IoT Enabled Smart Air Pollution Monitoring System

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**ABSTRACT:** India now has the World's Worst Air Pollution. Industrialization, coal-fired power plants, and a lack of regulation mean the problem is just going to get worse, even as richer nations clean up their Air. India's toxic Air is now contributing to over a million deaths a year, and the country is on its way toward standing alone as the site of the deadliest Air Pollution problem on the planet. From 2010 to 2015, the number of premature deaths caused by Air Pollution each year has gone from 957,000 to about 1.1 million [2]. India is far from the only country that needs to think hard about the detrimental health effects of polluted Air as it pursues economic growth. With higher population density, and much larger number of Vehicles on road, the amount of pollutants emitted by the Vehicles are the main factor contributing in Pollution by producing harmful Gases (CO<sub>2</sub>, CO, NH<sub>3</sub>). We propose an advanced and Automated method to analyse the Gases which are contributing to Pollution. For this purpose, we are using Arduino or Raspberry Pi. An Arduino is a microcontroller motherboard. A microcontroller is a simple computer that can run one program at a time, over and over again. It is very easy to use. A Raspberry Pi is a general-purpose computer, usually with a Linux operating System, and the ability to run multiple programs.

In our Proposed System, we have used an embedded System which has Sensors capable to detect and analyse three main contributing Gases in Air Pollution which are CO<sub>2</sub>, CO and NH<sub>3</sub>. Our System gathers these three Gases in ppm then data will be send to Server side. Considering the amount of data, the processing of the data will be difficult on Server side so we will transfer that data to the Cloud from Server for aggregation operation and is analysed to give one aggregate value which will be compared to standard number (Threshold) and If the value is greater than the standard value will conclude that particular Vehicle is contributing in Pollution. According to that conclusion owner of that Vehicle and RTO officer will receive alert message so that owner and Authority would able take appropriate action.

**KEYWORDS:** Air Pollution, Raspberry Pi, Arduino, Cloud, Sensors, IoT.

## I. INTRODUCTION

II. Day by day the number of Vehicles is increasing very fast. In major cities like Delhi, Mumbai and Pune number of Vehicles is far more. Due to imperfect combustion in the Vehicle engine the Pollution through Vehicle increases. Increasing number of Vehicles tend to increase in CO<sub>2</sub> concentration in the atmosphere. According to Mumbai Pollution control board, Pollution levels particularly NO<sub>x</sub>, and SPM perched particulate matter increased rapidly. SPM above 100 μ gram/cubic meter and NO<sub>x</sub> 88 μ gram/cubic meter is very harmful for health. The main sources of Pollution in metro cities like Mumbai, Delhi, Pune and Bangalore are Vehicles. The imperfect (incomplete) combustion in the engine of a Vehicle leads to emission of different harmful Gases leading to increase in the Pollution and unfavourably affecting the environment. Detection and control of these Gases emission source in the environment is an important area of work. Emission of these Gases from Vehicles cannot be completely avoided but, it definitely can be controlled. As a solution to above problem, we propose an advanced and Automated method to analyse the Gases which are contributing to Pollution. In our Proposed System, we have used an embedded System which has Sensors capable to detect and analyse three main Gases which are main factors in Pollution which are CO<sub>2</sub>, CO and NH<sub>3</sub>. The System is organized with Hardware design and methodology

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## II. SYSTEM ARCHITECHTURE

1. Using MQ 135 sensor, we will sense the harmful Gases which are coming from Vehicle e.g.CO<sub>2</sub>, NH<sub>3</sub>, CO. MQ 135 is connected to Raspberry Pi using Jumping wires and Breadboard.
2. The readings of Gases are calibrated and then calculated in terms of ppm (Particle per Million) and those readings are stored in the Database installed in Raspberry Pi.
3. After every 10 min, the sensor will take the reading and it will store in Database.
4. Whenever Raspberry Pi will get any Internet connection automatically, it will send all the data to Server machine.
5. After that, Server machine will import the data into its Database and it will perform aggregations operations.
6. After that, one value will be obtained at the end of the day and it will get compared to Threshold value. If obtained value is greater than Threshold value then the Vehicle owner and RTO officer will get a warning message with the corresponding Vehicle ID.
7. For power supply to Raspberry Pi, we will get a charging cable from Vehicle.

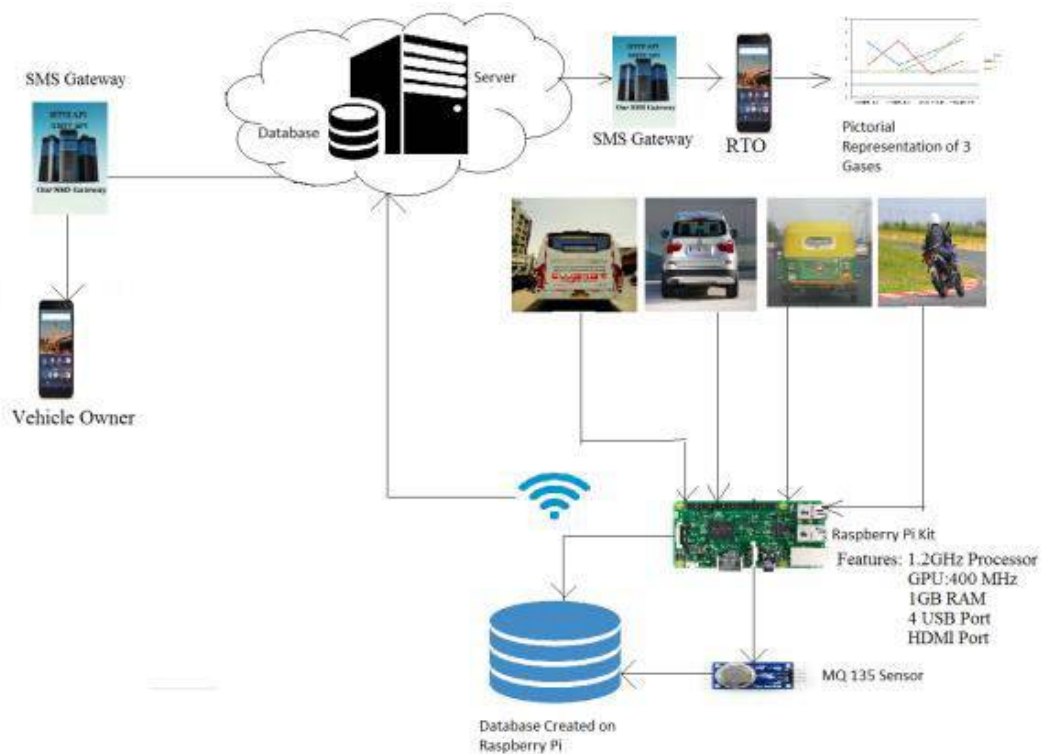


Fig.1.System Architecture of Data Transmission from Vehicle to Respective Authority.

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## A. Working Principle:

We propose an Advanced and Automated method to analyse the Gases which are contributing to Pollution. In our Proposed System, we have used an embedded System which has Sensors capable to detect and analyse three main Gases which are main factors in Pollution which are CO<sub>2</sub>, CO and NH<sub>3</sub>. Our System gathers these three Gases in ppm and is analysed to give one aggregate value which will be compared to standard number (Threshold) and if that value is greater than standard value will conclude that particular Vehicle is contributing in Pollution. According to that conclusion owner of that Vehicle and RTO officer will receive alert message so that client and Authority would able take appropriate action.

## B. Raspberry Pi 3:

Raspberry Pi is an Embedded Device Resulting to create Sensor based System. This Device stores all the data (Values of Gases coming out of respective Vehicle) into its Database installed and sends that data to Server side whenever gets an internet connection.

### Specifications:

CPU	Quad Cortex A53@ 1.2 GHz
LAN	1 GB SDRAM
Storage	Micro-SD
Wireless	802.11n/Bluetooth 4.0
GPIO	40

## B.1 Arduino:

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board.

### Specifications:

CPU	ATmega328
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
STORAGE	32 KB (ATmega328) of which 0.5 KB used by bootloader
GPIO	14

## C. MQ-135 Gas Sensor:

MQ-135 gas sensor applies SnO<sub>2</sub> which has a lower conductivity in the clear Air as a gas-sensing material. In an atmosphere where there may be polluting gas, the conductivity of the gas sensor raises along with the concentration of the polluting gas increases. MQ-135 performs a good detection to smoke and other harmful gas, especially sensitive to ammonia, sulphide and benzene steam. Its ability to detect various harmful gas and lower cost make MQ-135 an ideal choice of different applications of gas detection. This Gas Sensor is used to sense three Gases particularly CO<sub>2</sub>, CO, NH<sub>3</sub> which are the main Contributors towards the Air Pollution. This Sensor is integrated with Embedded Device to Create Real Time Monitoring Device. This Sensor Senses the Gases in terms of ppm (Particle per Million).

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Vol. 7, Issue 4, April 2018

### Specifications:

1. Power: 2.5V ~ 5.0V
2. Dimension: 40.0mm \* 21.0mm
3. Mounting holes size: 2.0mm

### D. MCP 3008 ADC Chip:

The MCP3008 10-bit Analog-to-Digital Converter (ADC) combines high performance and low power consumption in a small package, making it ideal for embedded control applications. The MCP3008 features a successive approximation register (SAR) architecture and an industry standard SPI serial interface, allowing 10-bit ADC capability to be added to any PIC microcontroller. The MCP3008 features 200k samples/second, 8 input channels, low power consumption (5nA typical standby, 425 $\mu$ A typical active), and is available in 16-pin PDIP and SOIC packages. Applications for the MCP3008 include data acquisition, instrumentation and measurement, multi-channel data loggers, industrial PCs, motor control, robotics, industrial automation, smart Sensors, portable instrumentation and home medical appliances.

### III. EXPERIMENTAL RESULTS

The Developed System is innovative in the sense that it will be mounted on every Vehicle and helps in real-time Monitoring and alert mechanism for keeping Pollution under check. It is real time, all time Monitoring of the polluting Gases. It is an integration of processing unit and the sensor which monitors the harmful Gases real time using gas sensor. This System is cost effective and requires very less capital investment. We propose an advanced and Automated method to analyse the Gases which are contributing to Pollution. In our ProposedSystem, we have used an embedded System which has Sensors capable to detect and analyse three main Gases which are main factors in Pollution which are CO<sub>2</sub>, CO and NH<sub>3</sub>. Our System gathers these three Gases in ppm and is analysed to give one aggregate value which will be compared to standard number (Threshold) and if that value is greater than standard value will conclude that particular Vehicle is contributing in Pollution. According to that conclusion owner of that Vehicle and RTO officer will receive alert message so that owner and Authority would able take appropriate action.

Prototype Description (Fig 2): This is prototype of real time PollutionMonitoringSystem. This prototype consists of integration of all the components i.e. Raspberry pi, MQ-135 Gas Sensor, Bread board, Jumping wires, ADC converter.

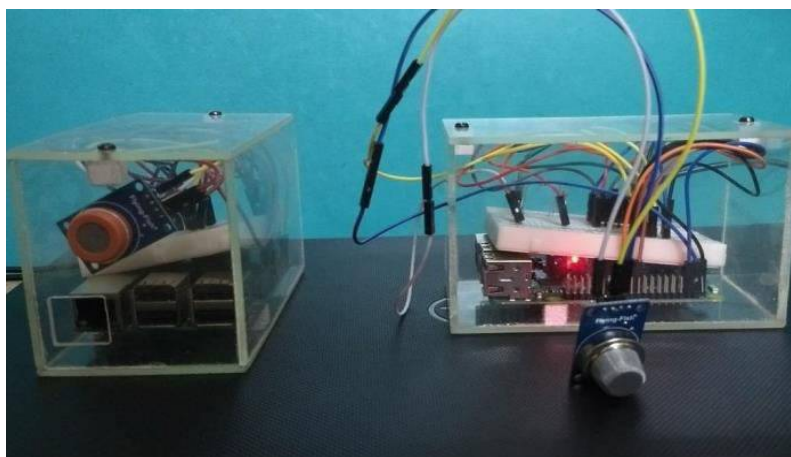


Fig. 2. Integration of Embedded Device and Sensor.

Prototype Validation (Fig 3): This is the Actual Implementation of our prototype on vehicle. In this we have placed AirPollutionMonitoringDevice anywhere inside the vehicle, and we are placing gas sensor at the tip of exhaust so the sensor can monitor (real time) gases which are coming from vehicle exhaust.

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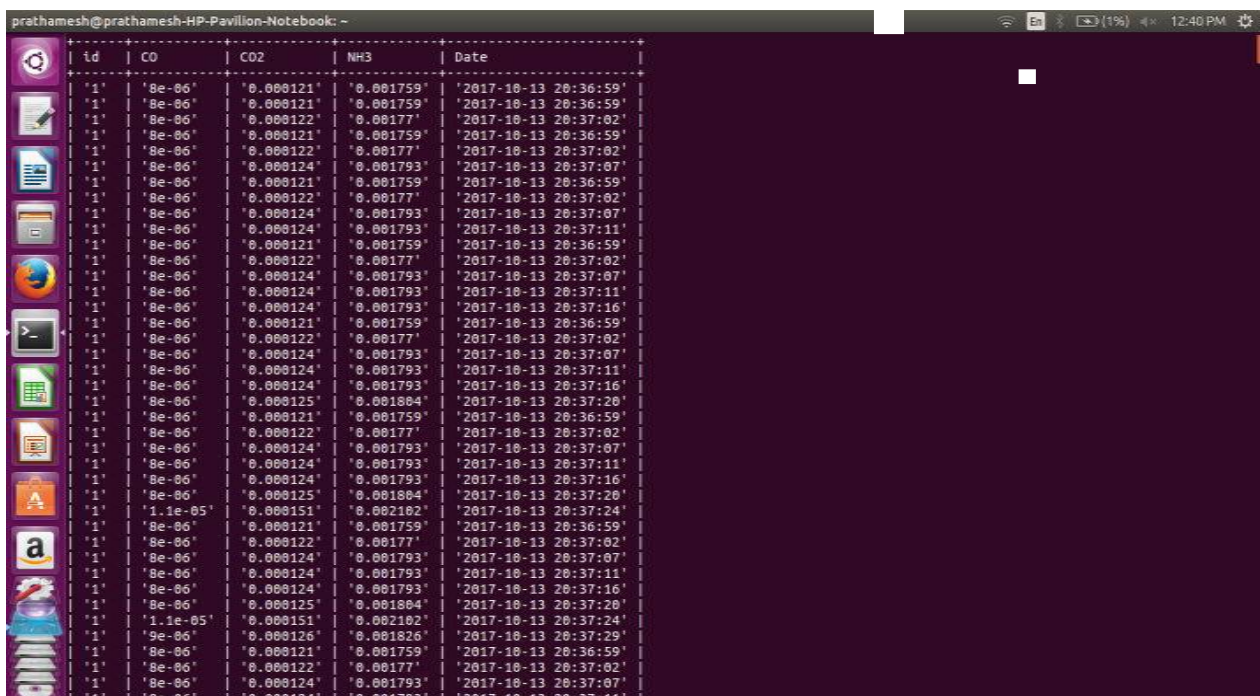
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Vol. 7, Issue 4, April 2018



Fig. 3 Prototype Validation

Result set (Fig 4): Below figure is image of result table, in which it shows gas emission results of any particular vehicle according to vehicle id, date & time. It displays emission of gases like CO, CO<sub>2</sub>, NH<sub>3</sub> in terms of ppm (particle per million).



id	CO	CO2	NH3	Date
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000122'	'0.00177'	'2017-10-13 20:37:02'
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000122'	'0.00177'	'2017-10-13 20:37:02'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:07'
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000122'	'0.00177'	'2017-10-13 20:37:02'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:07'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:11'
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000122'	'0.00177'	'2017-10-13 20:37:02'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:07'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:11'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:16'
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000122'	'0.00177'	'2017-10-13 20:37:02'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:07'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:11'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:16'
'1'	'8e-06'	'0.000125'	'0.001804'	'2017-10-13 20:37:20'
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000122'	'0.00177'	'2017-10-13 20:37:02'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:07'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:11'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:16'
'1'	'8e-06'	'0.000125'	'0.001804'	'2017-10-13 20:37:20'
'1'	'1.1e-05'	'0.000151'	'0.002102'	'2017-10-13 20:37:24'
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000122'	'0.00177'	'2017-10-13 20:37:02'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:07'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:11'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:16'
'1'	'8e-06'	'0.000125'	'0.001804'	'2017-10-13 20:37:20'
'1'	'1.1e-05'	'0.000151'	'0.002102'	'2017-10-13 20:37:24'
'1'	'8e-06'	'0.000126'	'0.001826'	'2017-10-13 20:37:29'
'1'	'8e-06'	'0.000121'	'0.001759'	'2017-10-13 20:36:59'
'1'	'8e-06'	'0.000122'	'0.00177'	'2017-10-13 20:37:02'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:07'
'1'	'8e-06'	'0.000124'	'0.001793'	'2017-10-13 20:37:11'

Fig.4.Result Set with Vehicle ID and Emission of Gases

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Vol. 7, Issue 4, April 2018

## IV. SUMMARY & CONCLUSION

In day today's life environmental problems are growing rapidly. Major cause factor behind this pollution is air pollution, air pollutants from car buses and trucks particularly ground level ozone and particulate matter can worsen respiratory diseases and trigger asthma attack. Transportation can be responsible for more than 50 percent of carbon monoxide in the air. In order to control the air pollution, the amount of air pollution needs to be monitored and vehicle responsible for polluting should be identified. For that we have created an IoT and cloud-based air pollution monitoring system which becomes helpful in cities for monitoring air pollution from vehicles. This sensor senses the gases (CO, CO<sub>2</sub>, and NH<sub>3</sub>) after a particular interval of time which are coming from exhaust and this data can be recorded in a system's database. When our system comes in contact with a network, the network is connected to the system then this data can be sent to the server machine, after that the server machine will import the data into its database and it will perform some aggregation operation. After the aggregation operation, one value will be obtained at the end of the day and it will be compared to the threshold value. If the obtained value is greater than the threshold value, the vehicle owner and RTO officer will get a warning message with the corresponding vehicle ID. This is our real-time system for monitoring and analyzing harmful gases. The main advantage of this system over PUC is that our system is real-time. We can implement and use this system in any commercial/government transport sector and automobile sector. By this we can monitor air pollution on a real-time basis. A low-cost, high-fidelity air quality monitoring device was designed, built, and tested. The device can collect data after a certain set period and transmit data via WiFi when the device comes in a network and notify the personnel depending on the threshold level. The GUI design gives a look to the functioning wireless CO, CO<sub>2</sub>, and NH<sub>3</sub> monitoring system, for sensing hazardous gases like CO, CO<sub>2</sub>, and NH<sub>3</sub> which are coming from vehicles. We are using (MQ-135) gas sensor to sense those gases. The information collected from the sensor was stored in a database and made available for displaying. The air monitoring system overcomes the problem of highly polluted areas which is a major issue. It supports the new technology and effectively supports the healthy life concept. So, it becomes very reliable and efficient for the municipal officials along with the civilians to monitor the environment. Letting civilians also involve in this process adds an extra value to it. As civilians are now equally aware and curious about their environment, this concept of IoT-enabled smart air pollution monitoring system is beneficial for the welfare of the society and it is implemented using the latest technology.

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