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Portable Pollution Monitoring System

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ABSTRACT: Now-a-days air pollution is one of the most important concerns of the world. Air pollution may evolve from anthropogenic or natural sources. Air pollutants of atmospheric substances like CO, CO₂, SO₂, NO₂, and O₃ suspended particulate matter (SPM), respirable suspended particulate matter (RSPM), and volatile organic compounds (VOCs) have a great effect on people's health. Most of the major cities in developing countries and most cities of the developed countries are suffering from it. Thus, developing a pollution monitoring system is critical. We have developed an Arduino based air pollution detector which combines a small-sized, minimum-cost sensor to an Arduino microcontroller unit. The advantages of the detector are reliable stability, rapid response recovery and long-life features. It is affordable, user-friendly, low-cost and minimum-power requirement hardware which is appropriate for mobile measurement, as well as comprehensible data collection. It has processing software able to analyze, collected quality data with high precision. Simple instrument which can be commercially utilized.

KEYWORDS: Air pollution, Arduino, gas sensor, anthropogenic, atmosphere.

I. INTRODUCTION

Air pollution is the presence of extra unwanted biological molecules, particulates or other harmful things into the earth's atmosphere. It is a major cause of infections, allergies, and eventually reasons of death to some people. It also harms other existing creatures like animals as well as food crops, or the ecological or built environment [1-2]. They are also accountable for various kinds of respiratory infections (like asthma), causes of different types of cancer in individuals, if they are unprotected to these toxins or chemicals for a long period of time. For example, carbon monoxide (CO) is extremely poisonous to people as it may cause serious asphyxiation, headaches because of the composition of carboxy-haemoglobin and thus a reason for death if unprotected for a long time. The world health organization (WHO) in 2014 estimated that 7 million people died worldwide because of air pollution. The similar approximation roughly equalled by the International Energy Agency (IEA) also [3]. These chemicals or pollutants are also responsible for various environmental calamities like acid rain and depletion of ozone layer. Because of a number of anthropogenic actions, air pollution is on the growth and its controlling is of significant importance to alleviate particular actions to limit it [4].

In the past, the air quality measuring sensors were very big, non-portable and expensive. Presently, most air pollution sensors developed on five most common air pollutants viz. nitrous oxide, carbon monoxide, ozone, sulphur dioxide and particulate matter. In today's world, air pollution and quality monitoring are really vital as it has a great effect on human health. The developed air-quality measurement sensor can identify and observe the incidence of air pollution in the adjacent areas. It can be employed for both indoor and outdoor use. With the help of future technological improvements, these sensors will become cheaper and more common, inexpensive, portable air-quality sensors which can be wearable by people to observe the local air quality [5-7].

II. PROBLEM STATEMENT

Nowadays the number of vehicles is extensively increasing. The exhaust gasses coming out from the exhaust manifold of the vehicle are polluted with several harmful gasses. These are Nitrogen dioxide (NO_x), Carbon monoxide (CO), Carbon dioxide (CO₂), Hydrocarbons, Particulate matter. To monitor the emission from the vehicles we have to conduct PUC tests. The pollution under control machine (PUC) is comparatively large and generally set up in a vehicle (4-Wheeler) so when we have to conduct pollution under control (PUC) tests either we have to go to the PUC vehicle or that vehicle has to come to our location.

III. METHODOLOGY

To overcome the problem of large PUC machines, a machine or a device has to be developed which is capable of transporting everywhere, easily and without any damage. The device has to maintain its accuracy and efficiency in

monitoring the gasses from the exhaust of the vehicle. The emissions of the vehicle have to be monitored and controlled. These emissions should be within the limits set under the Bharat Stage Emission Standards by the Central Pollution Control Board (CPCB).

Emission Standards for Light Duty Vehicles ⁱⁱⁱ							
Petrol Vehicles	Unit	BS-IV Norms			BS-VI Norms		
		M & N1 Class I	N1 Class II	N1 Class III	M & N1 Class I	N1 Class II	N1 Class III
CO	g/ km	0.50	0.63	0.74	0.50	0.63	0.74
HC	g/ km	-	-	-	-	-	-
HC+NOx	g/ km	0.30	0.39	0.46	0.17	0.195	0.215
NOx	g/ km	0.25	0.33	0.39	0.08	0.105	0.125
PM	g/ km	0.025	0.04	0.06	0.0045	0.0045	0.0045
Diesel Vehicles	Unit	M & N1 Class I	N1 Class II	N1 Class III	M & N1 Class I	N1 Class II	N1 Class III
CO	g/ km	1.00	1.81	2.27	1.00	1.81	2.27
HC	g/ km	0.10	0.13	0.16	0.10	0.13	0.16
HC+NOx	g/ km	-	-	-	-	-	-
NOx	g/ km	0.08	0.10	0.11	0.060	0.075	0.082
PM	g/ km	-	-	-	0.0045	0.0045	0.0045

Figure 1 BS 6 EMISSION NORMS

To regulate the emissions from the vehicle, the owners of the vehicle have to be informed about their emissions. So, every Traffic Police Officer has to make an initiative to do the necessary. To make this possible, a device and a technology is developed which is small in size and can monitor the extent of emissions from vehicles efficiently and accurately. In this project we have constructed a device that can monitor the two main and more harmful components of the exhaust gas: Carbon Dioxide (CO₂) and Carbon Monoxide (CO).

IV. THEORY

4.1 Components used in the project: For constructing the model, we have used the following components:

4.1.1 MQ-135 Gas sensor:

The gas sensor module consists of a steel exoskeleton under which a sensing element is housed. This sensing element is subjected to current through connecting leads. This current is known as heating current through it, the gasses coming close to the sensing element get ionized and are absorbed by the sensing element. This changes the resistance of the sensing element which alters the value of the current going out of it.



Figure 2 MQ-135 Gas Sensor Sensing Element

Pin Configuration MQ-135 gas sensor

From left to right first pins are as follows:

A0 Analog output

D0 Digital output

GND Ground

Vcc Supply (5V)

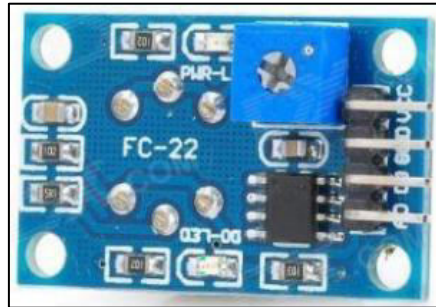


Figure 3 MQ-135 Sensing Module

Specifications of MQ-135 gas sensor

- Wide detecting scope
- Fast response and High sensitivity
- Stable and long-life Simple drive circuit
- Used in air quality control equipment for buildings/offices, it is suitable for detection of NH₃, NO_x, alcohol, Benzene, smoke, CO₂, etc.
- Size: 35mm x 22mm x 23mm (length x width x height) • Working voltage: DC 5 V
- Signal output instruction.
- Dual signal output (analog output, and high/low digital output)
- 0 ~ 4.2V analog output voltage, the higher the concentration the higher the voltage.

When we hold the sensor at the exhaust of the vehicle, the gas enters in the sensing element of the sensor and determines the gas and its extent. The sensor then sends the signal to the Arduino depending on the gas and its extent.

4.1.2. MQ-9 Gas sensor:



Figure 4 MQ-9 Sensing Element

MQ-9 Gas sensor has high sensitivity to Carbon Monoxide, Methane and LPG. The sensor can be used to detect different gases containing CO and combustible gases, it is low cost and suitable for different applications. Sensitive material of MQ-9 gas sensor is SnO₂, which has a lower conductivity in clean air. It makes detection by cycling high and low temperature, and detects CO when low temperature (heated by 1.5V). The sensor's conductivity is higher along with the gas concentration rising. When high temperature (heated by 5.0V), it detects Methane, Propane etc combustible gas and cleans the other gases adsorbed under low temperature.

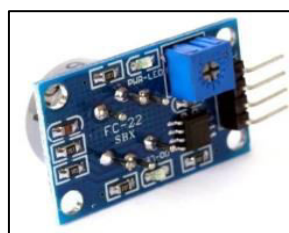


Figure 5 MQ-9 Sensing Module

Specification

- Power supply needs: 5V
- Interface type: Analog
- Sensor Type: Semiconductor
- Concentration:
 - 10-1000ppm CO
 - 100-10000ppm combustible gas
- Good sensitivity to CO/Combustible gas
- High sensitivity to Methane, Propane and CO
- Long life and low cost
- Size: 36.4x26.6mm

When we hold the sensor at the exhaust of the vehicle, the gas enters in the sensing element of the sensor and determines the gas and its extent. The sensor then sends the signal to the arduino depending on the gas and its extent.

4.1.3 Arduino UNO Micro-controller:

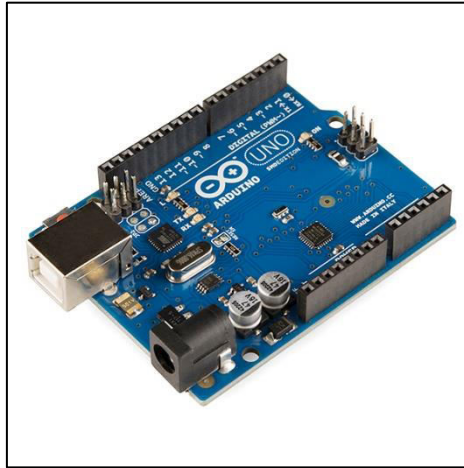


Figure 6 Arduino UNO

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller (MCU) and developed by Arduino.cc and initially released in 2010. The microcontroller board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by a USB cable or a barrel connector that accepts voltages between 7 and 20 volts, such as a rectangular 9-volt battery. It has the same microcontroller as the Arduino Nano board, and the same headers as the Leonardo board. The word "uno" means "one" in Italian and was chosen to mark a major redesign of the Arduino hardware and software. The Uno board was the successor of the Duemilanove release and was the 9th version in a series of USB-based Arduino boards. Version 1.0 of the Arduino IDE for the Arduino Uno board has now evolved to newer releases. The ATmega328 on the board comes preprogrammed with a bootloader that allows uploading new code to it without the use of an external hardware programmer.

While the Uno communicates using the original STK500 protocol, it differs from all preceding boards in that it does not use a FTDI USB-to-UART serial chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

4.1.4 Global System for Mobile Communication:



Figure 7 SIM 900 GSM Module

A GSM module or a GPRS module is a chip or circuit that will be used to establish communication between a mobile device or a computing machine and a GSM or GPRS system. The modem (modulator-demodulator) is a critical part here. The GSM module demonstrates the use of AT commands. They can feature all the functionalities of a mobile phone through a computer like making and receiving calls, SMS, MMS, etc. These are mainly employed for computer-based SMS and MMS services. The GSM module is coded to send a message in the case, when the pollution level i.e. the CO and CO₂ level has crossed the norms. The message is as, “POLLUTION IS NOT UNDER CONTROL” and also the values of CO and CO₂ content.

4.1.5 Liquid crystal display:



Figure 8 LCD I2C Display

Liquid Crystal Display (LCD) is a power economical, thin, flat-panel display (characters and animations), easily programmable, and used in various digital devices and circuits. It employs a matrix structure in which the active element forming the pixel cell is located in the intersection of two electrode buses. Particularly, the 16x2 LCD used in

the implemented prototype is able to display data over 2 lines, each of 16 characters. In our system the LCD is used to show the output parameters to the user.

4.1.6. Power Pack:

The power pack is made up of three rechargeable Lithium cells of NMC chemistry connected in series. The cell specification is as follows.

NO.	Item	Specifications
4.1	Typical Capacity	1200mAh @ 0.2C Discharge
	Minimum capacity	1150mAh @ 0.2C Discharge
4.2	Nominal voltage	3.7V
4.3	Standard Charge	CC/CV,0.2C5A, 4.20V
4.4	Standard Discharge	CC,0.2C5A,3.00V
4.5	End-of-charge Voltage	4.20V±0.05V
4.6	End-of-charge Current	0.01C5A (At CV mode)
4.7	End-of-discharge Voltage	3.00 V
4.8	Charging Time	6.0hours (standard charge)
4.9	Quick Charge Current	600 mA (0.5C5rate)
4.10	Quick Discharge Current	1200mA
4.11	Max Discharge Current	1200mA
4.12	Initial Impedance	Max:60mQ

Table 1: Cell Specifications

4.2WORKING PRINCIPLE OF THE SYSTEM

The sensors analog pin is then related to the analog pin 0 and digital pin to digital 8 on the Arduino board, while +5V and the GND (ground) pins on the sensor unit are linked to the 5V VCC and GND (ground) pin correspondingly on the Arduino board. Using USB connection, the Arduino Nano board is then linked to a computer system. This part elaborates the hardware and software instruments and structural design of the detector. computer by a USB link or power. Connected to an AC-to-DC converter or battery source to become commenced. Using jumper wires the MQ135 gas sensor unit is linked to the Arduino nano board.

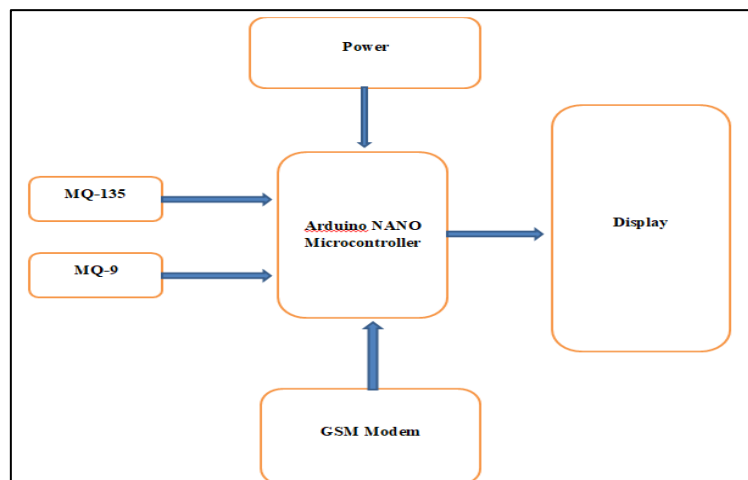
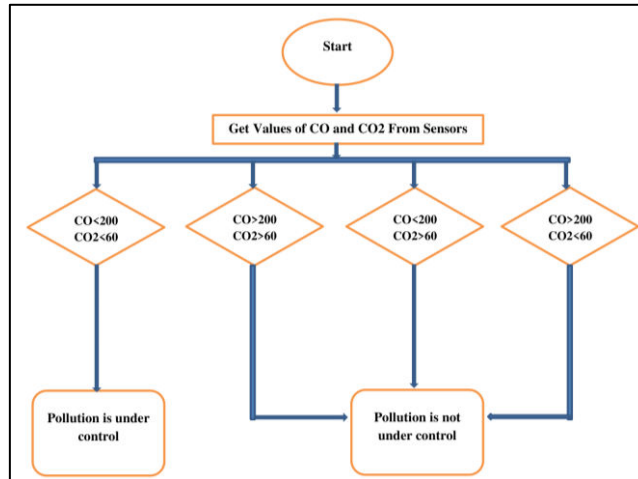


Figure 9 Working Principle

CODE DEVELOPMENT:

We have also developed a customize software s for gathering data from the detector and mapping it in real- time [10, 13]. The software of Arduino-based air pollution detector system comprises the coding of the Arduino UNO board in its Integrated Development Environment (Arduino IDE). The serial connection between the sensor, the Arduino, and the computer system that was formed using the serial library of the Arduino. The attention of the gas measured hinge on upon the resistance of the gas sensor. Additionally, this depends on the sensor of the voltage of the analogue output pin. The sensor revisits an analogue voltage to the Arduino [11, 14 -15].

Before developing the code, the logical algorithm was developed. The algorithm is given in chart below:



The code that is developed for the operation of system is as follows:

```

#include <SoftwareSerial.h>
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x3f,16,2);
SoftwareSerial mySerial(11, 10);
int GASval1=0;
int GASval2=0;
int gvd1, gvd2;
void setup()
{
  pinMode(3,OUTPUT);
  pinMode(4, INPUT);
  pinMode(5, INPUT);
  Serial.begin(9600);
  mySerial.begin(9600);
  lcd.init();
  lcd.clear();
  lcd.backlight();
  lcd.clear();
  lcd.print(" WELCOME ");
  delay(2000);
}

void loop()
{
  GASval1=analogRead(A0); //CO2 gas
  GASval2=analogRead(A2); //CO gas
  gvd1=digitalRead(4);
  gvd2=digitalRead(5);

  Serial.println(gvd1);
  Serial.println(gvd2);
  Serial.println("-----");
  lcd.clear();
  lcd.print("CO2= ");
  lcd.setCursor(4,0);
  lcd.print(GASval1);
  lcd.setCursor(9,0);
  lcd.print("CO= ");
}
    
```



```

lcd.setCursor(12,0);
lcd.print(GASval2);
delay(1000);

if(GASval2 >200 || GASval1 >600)
  //CO gas      //CO2 gas
  {
    lcd.setCursor(0,1);
    lcd.print("    POLLUTED  ");
    digitalWrite(3,HIGH);
    delay(2000);
    sendmsgPoll();
  }
else
  {
    digitalWrite(3,LOW);
    lcd.setCursor(0,1);
    lcd.print("  NON POLLUTED  ");
    delay(2000);
    sendmsgNotPoll();
  }
}

```

```

void sendmsgPoll()
{
  mySerial.println("AT+CMGF=1"); // Configuring TEXT mode
  delay(1000);
  mySerial.println("AT+CMGS=\"+918600574333\"");
  //change ZZ with country code and xxxxxxxxxxx with phone r
  delay(1000);
  mySerial.print("POLLUTION IS NOT UNDER CONTROL  CO2= ");
  mySerial.println(GASval1);
  mySerial.print("CO= ");
  mySerial.print(GASval2);
  delay(1000);
  mySerial.write(26);
}

void sendmsgNotPoll()
{
  mySerial.println("AT+CMGF=1"); // Configuring TEXT mode
  delay(1000);
  mySerial.println("AT+CMGS=\"+918600574333\"");
  //change ZZ with country code and xxxxxxxxxxx with phone r
  delay(1000);
  mySerial.print("POLLUTION IS UNDER CONTROL  CO2= "); //te
  mySerial.println(GASval1);
  mySerial.print("CO= ");
  mySerial.print(GASval2);
  delay(1000);
  mySerial.write(26);
}

```

V. COST ESTIMATION

Sr. No.	Name of the Component	Price (₹)
1	MQ-135	200
2	MQ-9	100
3	Arduino UNO	800
4	SIM 900 GSM Modem	780
5	LCD	250
6	Jumper Wires	50

Table 2: Cost Estimation

VI. RESULTS AND DISCUSSION

The actual image of the hardware system is displayed below:

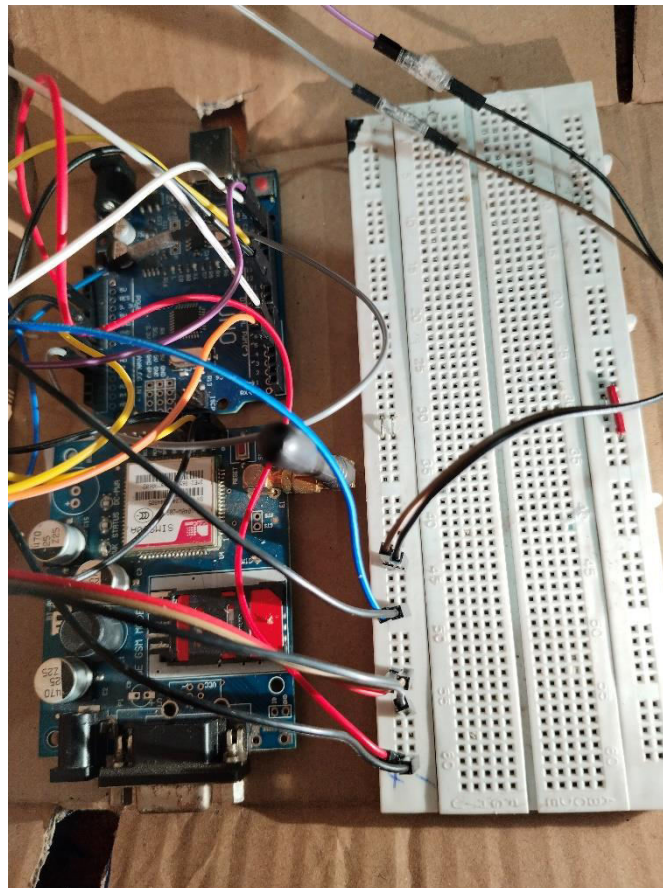


Figure 10 Hardware System Developed

During Testing of the device, the Pollution Under Control (PUC) Test had been performed on twelve vehicles. Their data is as listed below:

Sr. No.	Vehicle No	CO (ppm)	CO ₂ (ppm)
1	MH 14 EA 8858	174	545

2	MH 14 CA 6521	365	876
3	MH 12 EA 3971	155	467
4	MH 12 AK 1647	428	943
5	MH 12 BH 5498	258	681
6	MH 16 AT 1155	365	762
7	MH 16 CN 1001	330	1268
8	MH 01 DG 5487	458	1050
9	MH 02 BT 9468	545	1263
10	MH 12 EA 8520	184	468
11	MH 14 KS 9630	168	764
12	MH 40 AT 4714	384	1256

Table 3: Results Obtained During Testing

VII. CONCLUSION

As it can be seen from the above results obtained by testing the Portable Pollution Monitoring System, only 3 vehicles out of the 12 were found to be non-polluted and 9 vehicles were found to be polluted.

Polluted Vehicles (P) = 9

Non-Polluted vehicles (NP) = 3

∴ Ratio of Polluted Vehicles to Non-Polluted Vehicles

$$\frac{\text{Polluted Vehicles}}{\text{Non - Polluted Vehicles}} = \frac{P}{NP} = \frac{9}{3} = 3:1$$

This ratio might not seem large, but the number of vehicles in the world is quite large and thus the number of the polluted vehicles. By giving the Traffic Officers this system, they can check the pollution of the individual vehicles, fast and accurate. This can bring awareness among the vehicle users more effectively. If the pollution by vehicles is kept under control, then life on earth will be Cleaner and Healthier.

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