Visvesvaraya Technological University

Belgaum, Karnataka-590 018

A Project Report on

"An IOT Based Air Pollution Control System"

Project Report submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Engineering
In
Electrical & Electronics Engineering

Submitted by

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Certificate

Certified that the project work entitled **"An IOT Based Air Pollution Control System"** carried out by Mr. Anubhav Aryan, USN 1CR17EE008; Mr. Jnanesh B S, USN 1CR17EE026; Ms. Pramita Soans, USN 1CR17EE048; Ms. Prateeksha S H, USN 1CR17EE049 are bonafied students of CMR Institute of Technology, Bengaluru, in partial fulfillment for the award of Bachelor of Engineering in Electrical & Electronics Engineering of the Visvesvaraya Technological University, Belgaum, during the year 2020-2021. It is certified that all corrections/suggestions indicated for Internal Assessment have been incorporated in the Report deposited in the departmental library.

The project report has been approved as it satisfies the academic requirements in respect of Project work prescribed for the said Degree.

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DECLARATION

We, [Mr. Anubhav Aryan(1CR17EE008); Mr. Jnanesh B S(1CR17EE026); Ms. Pramita Soans (1CR17EE048); Ms. Prateeksha S H(1CR17EE049**)**], hereby declare that the report entitled **"An IOT Based Air Pollution Control System"** has been carried out by us under the guidance of **Dr. Ramesh P,** Professor, Department of Electrical & Electronics Engineering, CMR Institute of Technology, Bengaluru, in partial fulfillment of the requirement for the degree of **BACHELOR OF ENGINEERING in ELECTRICAL & ELECTRONICS ENGINEERING**, of Visveswaraya Technological University, Belgaum during the academic year 2020-21. The work done in this report is original and it has not been submitted for any other degree in any university.

Place: Bengaluru
Date:04/01/2021

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Abstract

Air pollution is the largest environmental and public health challenge in the world today. Air pollution leads to dire effects on Human health, climate and ecosystem as a whole. Air pollution is caused by solid and liquid particles and certain gases that are suspended in the air. These particles and gases can come from car and truck exhaust, factories, dust, pollen, mold spores, volcanoes and wildfires. Particulate matter is one of the most important parameters having the significant contribution to the increase in air pollution. This creates a need for measurement and analysis of real-time air quality monitoring so that appropriate decisions can be taken in a timely period to control the same. This project presents a real-time air quality monitoring and control system. Internet of Things, which is nowadays finding profound use in each and every sector, plays a key role in our air quality monitoring and control system too. Internet of Things converging with cloud computing offers a novel technique for better management of data coming from different sensors, collected and transmitted by low power, low-cost ARM based minicomputer Raspberry pi.

Acknowledgement

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mention of people, who are responsible for the completion of the project and who made it possible, because success is outcome of hard work and perseverance, but steadfast of all is encouraging guidance. So, with gratitude we acknowledge all those whose guidance and encouragement served us to motivate towards the success of the project work.

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We would like to convey our sincere gratitude to ***Dr. K Chitra****,* ***Head of Electrical and Electronics Engineering Department, CMR Institute of Technology, Bengaluru*** *for her invaluable guidance and encouragement and for providing good facilities to carry out this project work.*

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We are thankful to all the faculties and laboratory staffs of ***Electrical and Electronics Engineering Department, CMR Institute of Technology, Bengaluru*** *for helping us in all possible manners during the entire period.*

Finally, we acknowledge the people who mean a lot to us, our parents, for their inspiration, unconditional love, support, and faith for carrying out this work to the finishing line. We want to give special thanks to all our friends who went through hard times together, cheered us on, helped us a lot, and celebrated each accomplishment.

Lastly, to the ***Almighty****, for showering His Blessings and to many more, whom we didn't mention here.*

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LIST OF FIGURES

LIST OF ABBREVIATIONS AND SYMBOLS

WHO	World Health Organization
IAQ	Indoor Air Quality
WSN	Wireless Sensor Network
PPM	Parts per Million
HEPA	High Efficiency Particulate Air
VOC	Volatile Organic Compound

CHAPTER 1: INTRODUCTION

1.1 Brief Background of the Research

World Health Organization (WHO) measures both indoor and outdoor air pollution. They report more than 4 million people die each year from air pollution. Over the past years, air pollution has grown so prevalent that nearly everyone accepts the fact that it is increasing exponentially and continuously due to rapid growth in industrialization and vehicles. Air pollutants such as ground–level ozone, nitrogen dioxide, and Sulphur dioxide are harmful for nature. Chemical pollutants, including suspended particulate matter, carbon monoxide, oxides of nitrogen, oxides of Sulphur, lead aerosol, volatile organic compounds are harmful for health. Due to these pollutants the occurrence of diseases has increased.

Therefore, there is a huge demand to control and monitor such air pollutants. Monitoring gives measurements of air pollutant, which can then be analyzed, interpreted and presented. Analysis of monitoring data allows us to assess how bad air pollution day to day. And with this information we can takes measures to control the air pollution.

Advanced studies in the technology of sensor network and wireless communications have contributed a wide range of applications of wireless sensor network in environmental monitoring and pollution control. We discuss here a detailed study on ambient air pollution monitoring and air quality control using sensor nodes in a wireless sensor network.

1.2 Contribution

This project addresses the rising levels of outdoor pollution and aims to minimize it by the application of modern technology and concepts for the welfare of the society. The project caters to the need by influencing and impacting both the environmental conditions and human health care positively.

1.3 Objectives of the Thesis

- To monitor concentrations of air pollutants
- To purify outdoor air by the means of a feedback mechanism that operates only if the air quality falls below the threshold value.

CHAPTER 2: LITERATURE REVIEW

Air pollution is a growing factor worldwide. People spend most of their time indoors—either at home, in the workplace, or in transit. Thus, there has been an increasing concern over indoor air quality (IAQ) and its effects on public health. The monitoring and control of five major pollutants, including PM_{10}, CO_2, CO, VOCs, and formaldehyde and many more in indoor environments and outside is important.

This project mainly focusses on how a sensor network is used in a wide range to monitor the levels of air pollutants such as CO2, NO2, SO2, PM, NH3 and other toxic gases present in an ambient place where a major human activities and industrial activities takes place. Role of WSN in air pollution monitoring involves deployment of sensor nodes in a large scale at very low cost and to collect the real-time data and produce accurate results.

Air pollution is a major risk factor for human health including respiratory problems, skin diseases, lung cancer, cardiovascular diseases and many more side effects. Most of the urban cities are affected by the poor air quality and sudden change in the climatic conditions. The levels of air quality in many cities are below the environmental quality standards.

CHAPTER 3: PROPOSED MODEL WITH THEORETICAL BACKGROUND

3.1 Monitoring System

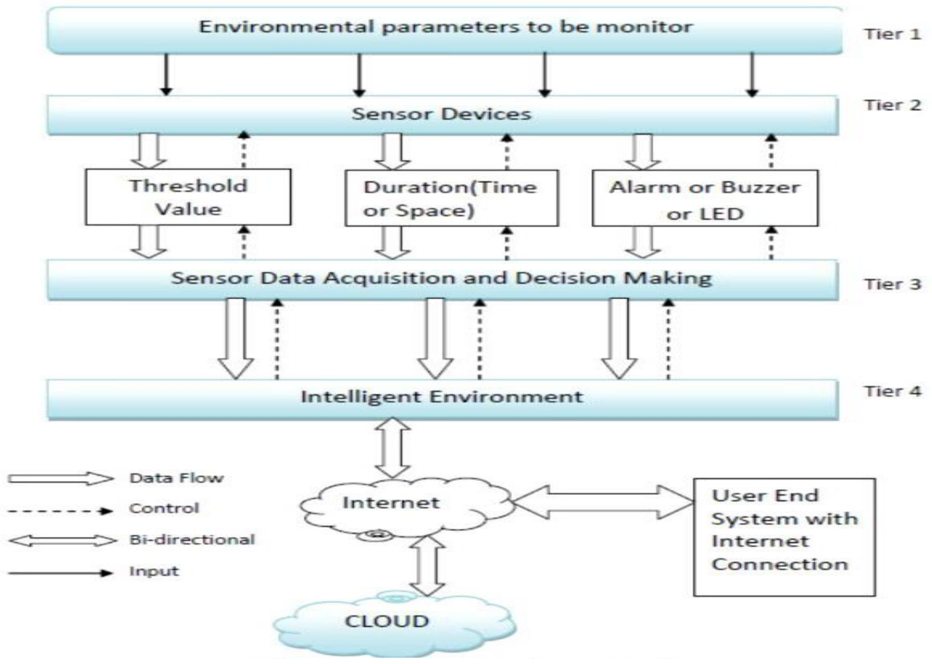

Fig1: Proposed model

3.1.1 Methodology

The MQ135 sensor can sense Ammonia, oxide of nitrogen, alcohol, Benzene, smoke, Carbon dioxide and some other gases, so it is perfect gas sensor for Air Quality Monitoring Project

When we will connect it to Arduino then it will sense the gases, and we will get the Pollution level in PPM (parts per million).

The sensor gives a value around 90 when there is no gas near it and the safe level of air quality is 350 PPM and it should not exceed 1000 PPM.

When the value will be less than 1000 PPM, then the LCD and webpage will display "Fresh Air". Whenever the value will increase 1000 PPM, then the buzzer/alarm will start beeping and the LCD and webpage will display "Poor Air".

If the quality of air deteriorates further then the buzzer/alarm will send the signal to the control system.

3.1.2 Flow Chart

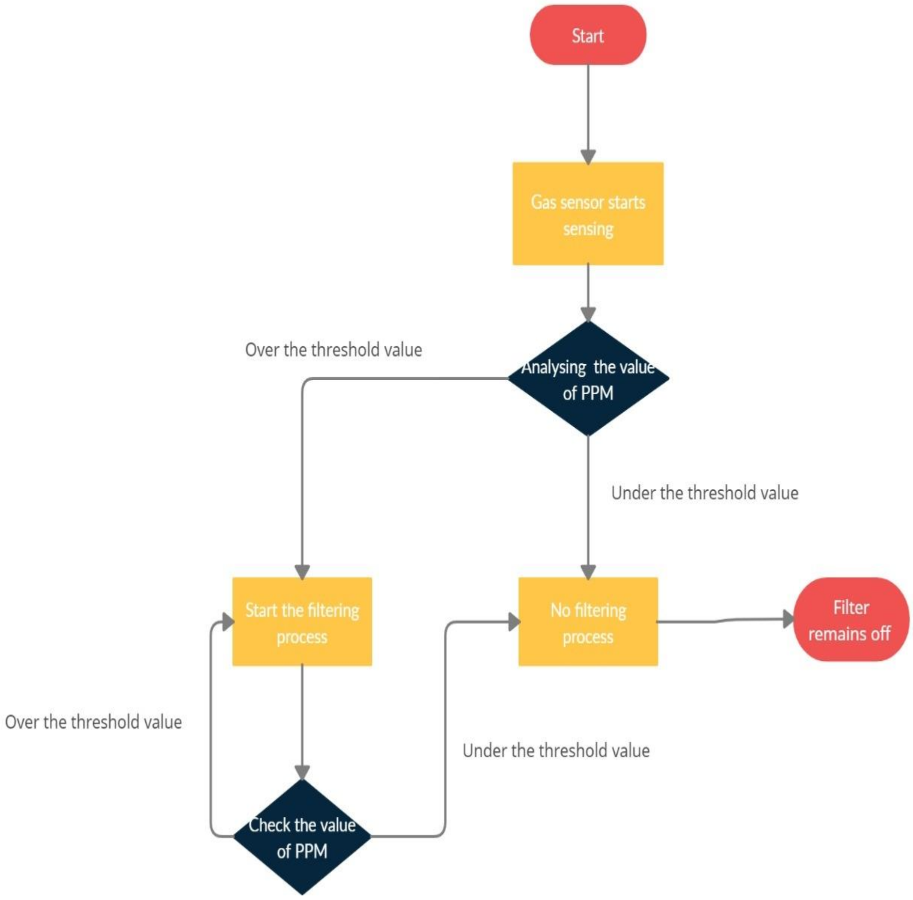

Fig 2. Flowchart – Working of IOT based monitoring system

3.1.3 Working Procedure

- The MQ-135 gas sensor consists of a Tin dioxide (SnO2), a perspective layer inside the micro tubes which are the measuring electrodes and a heating element. This sensor applies the SnO2 which has a higher resistance than the clear air as a gas sensing material.
- When there is an increase in the polluting gases, the resistance of the gas sensor decreases along with it.
- First the sensor is calibrated by measuring the value of resistance in clear air(R0) and the value of resistance of the sensor (Rs) is found by using the formula-
- Rs=(Vc/VRL-1) *RL
- After calculating the values of Rs and R0 the ratio can be found and then using the datasheet of MQ-135 sensor we can get the PPM for the particular gas.

- So, the sensor can be calibrated so that its analog output voltage is proportional to the concentration of polluting gases in PPM.
- Once the device is powered, the Arduino board loads the required libraries, flashes some initial messages on the LCD screen and start sensing data from the MQ-135 sensor.
- The analog voltage sensed at the pin A0 of the Arduino is converted to a digital value by using the in-built ADC channel of the Arduino. The digitized value can be assumed proportional to the concentration of gases in PPM.
- The read value is first displayed on LCD screen and passed to the ESP8266 module. The Wi-Fi module is configured to connect with the ThingSpeak IOT platform that allows to aggregate, visualize and analyze live data streams in the cloud.

3.2 Control System

3.2.1 Air Purifier

An air purifier is a device that purifies the air of particulates or gases.

The National Institute for Occupational Safety and Health (NIOSH) has approved seven classes of filters:

1. N95: Filters at least 95% of particles.
2. N99: Filters at least 99% of particles.
3. N100: Filters at least 99.97% of particles.
4. R95: Filters at least 95% of particles.
5. P95: Filters at least 95% of particles.
6. P99: Filters at least 95% of particles.
7. P100: Filters at least 99.97% of particles.

Air purifier filters utilize fine sieves that filter particles out of the circulating air. High Efficiency Particulate Air (HEPA) filters trap about 99.97% of airborne particles, which are larger than 0.3 microns in size. Each micron is equivalent to 1/25400 of an inch. Electrical attraction is another type of technology that air purifiers utilize to trap particles. There are three types under Electrostatic precipitating cleaners, Electret filters and Negative ion generators or Ionic air purifiers.

3.2.2 Air Flow Mechanism

To create an airflow across the purifying system we have employed Bernoulli's principle. As the Bernoulli principle states that an increase in the speed of a fluid occurs simultaneously with a decrease in the pressure exerted by the fluid, the same approach can be applied to the flow of air.

That is, when moving air encounters an obstacle its path narrows as it flows around the object. Even so, the amount of air moving past any point at any given moment within the airflow is the same. For this to happen, the air must either compress or speed up where its flow narrows. This is achieved by constructing the proposed model in the following manner.

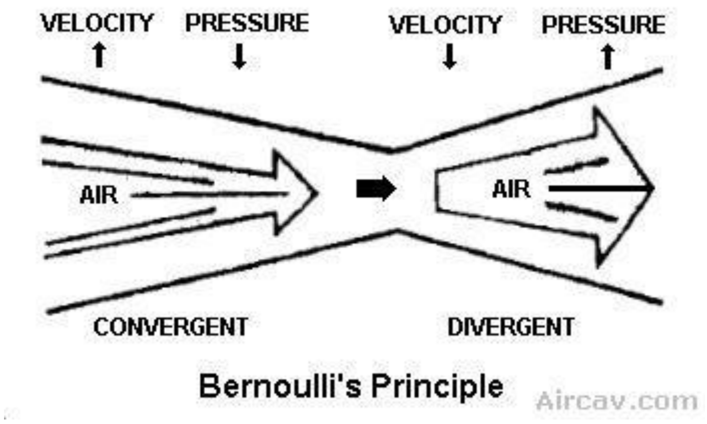

Fig3. Beroulli's Principle

This means that if the area in which the air is moving narrows or widens, then the air has to speed up or slow down to maintain a constant amount of air moving through the area.

This mechanism is employed with a suction fan at the beginning of the proposed model to maintain and increase the movement of air through the purifying mechanism.

3.2.3 Filter Mechanism

(a) Primary Filter or General Filter

When we talk about primary filtration, we mean filtration using filter media and cells that fall within class "G" according to the ISO 16890 standard, normally used in civil air conditioning and as prefilters for high efficiency filters.

The Pre-filters are a necessary tool that acts as the first line of defense. The pre-filters trap and remove large particulate matters with high-efficiency, which serves as a necessity to maintain high-life of the air cleaner. The pre-filter traps particles such as sand particles, cobwebs, large dust, human or pet hair and debris.

For this process three types of filter can be used:

(i) Politex: It is a synthetic filter media allowing pre-filtration and separation of particulates with medium high granulometry

Fig4. Politex

(ii) Filter cel: It is a bed allowing filteration of large dust molecules.

Fig5. Filter cel

(iii) Alfa Bag filters: These are filter papers pleated at depth varying from a minimum of 5 MM to 50 MM and in a height varying from 30 MM to 1000 MM.

Fig6. Alfa Bag Filter

(b) Gas Filter – Specially Treated Carbon filter

Unlike solid particles, gas atoms and molecules inhabit an entirely different physical state.

In a gaseous state, atoms move about at much higher speeds than solid atoms do. They're also typically much smaller than solid particles, with an average diameter less than 0.001 microns.

The most important pollutants are:

- **Gaseous pollutants:** includes gas generated by combustion from vehicles as well as paints, varnishes, cleaning products etc.
- **Volatile organic compounds (VOCs):** VOCs are largely emitted by paint, furniture, chemicals, and other similar sources. Some VOCs can cause headaches, skin reactions, eye and respiratory tract irritation, and memory impairment. VOCs have also been linked to cancer. Formaldehyde is the most common VOC.
- **Toxic gases:** includes carbon monoxide, sulphur dioxide, and nitrogen dioxide. These gases can be fatal in large amounts. Even in small doses, some can cause respiratory problems and fatigue.

There are two main processes that remove gaseous pollution: **adsorption** and **chemisorption**

- Adsorption happens when atoms or molecules stick to the surface of an adsorbent and become physically bound together. The amount of gas that the adsorbent can hold is a certain percentage of the adsorbent's weight.
- Chemisorption happens when gas or vapour molecules chemically react with a sorbent or with reactive substances in the sorbent. This happens on the surface of the sorbent – no adsorption takes place. Chemisorption leaves water and oxygen as a by-product in the air.

To accomplish the toxic gas removal, we need to employ a filter that encourage both adsorption and chemisorption. Activated carbon (also called activated charcoal) is the most common adsorbent material used in air filtration. It can be made from coal, coconut shells, wood, and much more. Granular activated carbon is most effective because its large surface area allows it to adsorb many different compounds.

(c) Dust Filter – HEPA Filter

HEPA filters are composed of a mat of randomly arranged fibres The fibers are typically composed of fiberglass with diameters between 0.5 and 2.0 micrometers.

Fig7. HEPA Filter

CHAPTER 4: DESIGN PROCESS

4.1 Code for monitoring air pollution

Connections of the Monitoring System

Arduino to LCD
GND ==> GND
5 V ==> Vcc
D13 ==> RS
GND ==> R/W
D12 ==> Enable
D6 ==> DB4
D5 ==> DB5
D4 ==> DB6
D3 ==> DB7
5V ==> LED+
GND ==> LED-

Arduino to Gas sensor
GND ==> GND
3.3 V ==> Vcc
Analog0 ==> A0

Arduino to ESP8266
D10 ==> Tx
D11 ==> Rx

Source Code for monitoring air pollution

```
#include <SoftwareSerial.h>

#include <LiquidCrystal.h>



LiquidCrystal lcd (13, 12, 6, 5, 4, 3); // LCD connections

float t=0;

char data = 0;

String apiKey = “”; // Write API key

// connect 8 to TX of ESP

// connect 9 to RX of ESP

SoftwareSerial ser(8,9); // RX, TX

void setup()
```

```
{
// enable debug serial
  Serial.begin(9600); // serial data transmission at Baud rate of 9600
// enable software serial
  ser.begin(9600);
  lcd.begin(16, 2);  // to intialize LCD
  lcd.setCursor(0,0);
  lcd.print("    Welcome");
  lcd.setCursor(0,1);
  lcd.print("       To        ");
  delay (3000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("     AIR");
  lcd.setCursor(0,1);
  lcd.print("QUALITY MONITOR");
  delay(3000);
  ser.println("AT");  // Attenuation
  delay(1000);
  ser.println("AT+GMR"); // To view version info for ESP-01 output:
00160901 and ESP-12 output: 0018000902-AI03
  delay(1000);
  ser.println("AT+CWMODE=3"); // To determine WiFi mode
/*
1 = Station mode (client)
2 = AP mode (host)
3 = AP + Station mode (ESP8266 has a dual mode)
*/
  delay(1000);
  ser.println("AT+RST"); // To restart the module
  delay(5000);
```

```
  ser.println("AT+CIPMUX=1"); // Enable multiple connections
  /*
    0: Single connection
    1: Multiple connections (MAX 4)
*/
  delay(1000);
  String cmd="AT+CWJAP=\"SSID\",\"PASSWORD\""; // connect to Wi-Fi
  ser.println(cmd);
  delay(1000);
  ser.println("AT+CIFSR"); // Return or get the local IP address
  delay(1000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("      WIFI");
  lcd.setCursor(0,1);
  lcd.print("   CONNECTED");
 }
// the loop
void loop()
{
  delay(1000);
  t = analogRead(A0);  // Read sensor value and stores in a variable t
  Serial.print("Airquality = ");
  Serial.println(t);
  lcd.clear();
  lcd.setCursor (0, 0);
  lcd.print ("Air Qual: ");
  lcd.print (t);
  lcd.print (" PPM ");
  lcd.setCursor (0,1);
```

```
  if (t<=500)
   {
   lcd.print("Fresh Air");
   Serial.print("Fresh Air ");
}
  else if(t>=500 && t<=1000)
{
   lcd.print("Poor Air");
   Serial.print("Poor Air");
}
  else if (t>=1000 )
{
  lcd.print("Very Poor");
  Serial.print("Very Poor");
}
  //lcd.scrollDisplayLeft();
  delay(10000);
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("  SENDING DATA");

  lcd.setCursor(0,1);
  lcd.print("    TO CLOUD");
  esp_8266();
}
void esp_8266()
{
   // TCP connection AT+CIPSTART=4,"TCP","184.106.153.149",80
    String cmd = "AT+CIPSTART=4,\"TCP\",\"";  // Establish TCP
connection
    /*
```

```
 AT+CIPSTART=id,type,addr,port
 id: 0-4, id of connection
 type: String, “TCP” or “UDP”
 addr: String, remote IP
 port: String, remote port
 */
 cmd += "184.106.153.149"; // api.thingspeak.com
 cmd += "\",80";
 ser.println(cmd);
 Serial.println(cmd);
 if(ser.find("Error"))
 {
   Serial.println("AT+CIPSTART error");
   return;
 }
String getStr = "GET /update?api_key=";  // API key
getStr += apiKey;
//getStr +="&field1=";
//getStr +=String(h);
getStr +="&field1=";
getStr +=String(t);
getStr += "\r\n\r\n";
// send data length
cmd = "AT+CIPSEND=4"; // Send data AT+CIPSEND=id,length
cmd += String(getStr.length());
ser.println(cmd);
Serial.println(cmd);
delay(1000);
ser.print(getStr);
Serial.println(getStr);
```

```
// thingspeak needs 16 sec delay between updates
 delay(16000);
```

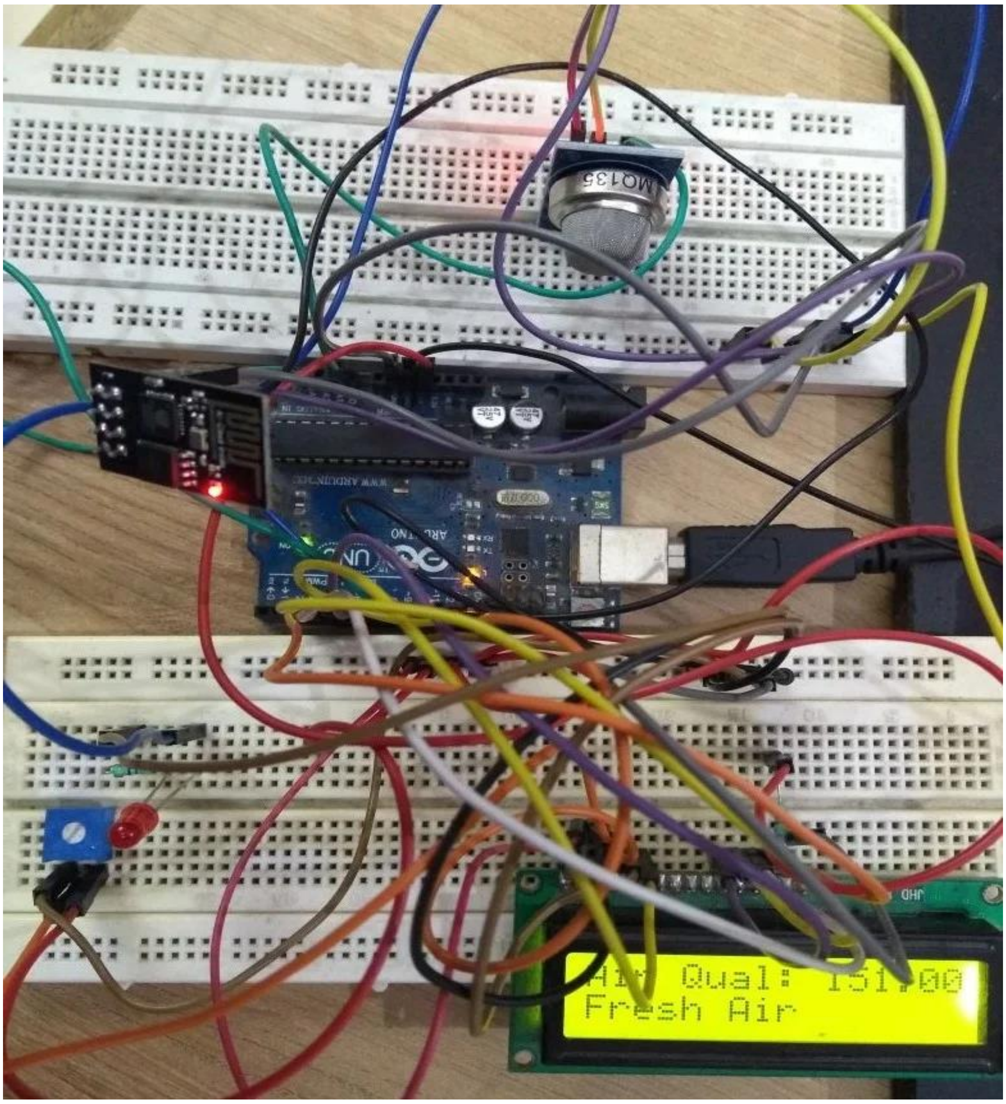

Fig 8. Circuit connection of IOT based monitoring system

4.2 Design Considerations for Air purifier Model

1. Volume and velocity

This is done by choosing the smallest cross section and calculating the volume needed to achieve the required velocity. The chosen velocity is most effective for keeping the chamber free from dust and therefore providing adequate filteration.

2. Pressure to minimise blockages

The pressure is the energy in the moving air and keeps the dust from losing velocity in the ducting and dropping out causing blockages.

The other aspect to take into consideration is the friction of the air through the filters which need energy to overcome especially when there is a loading of dust on the media.

3. Fan

Selection of a suction fan that eliminates overloading and has minimum power loss.

4. Filter

The filters are the heart and soul of the air purifying system. Selection of appropriate filters is very important. Care should be taken to maximise life of the filter.

Higher filter area = lower velocity = less maintenance = long life of filter

5. Cost Analysis

The more filters there are, the more area there is for the air to pass through so the velocity is much lower. The lower the velocity the longer the filter lasts and the less pressure the fan will have to produce. It is recommended that air to cloth ratio is of the ratio 2.212:1 critical to filter life.

4.3 Filter Design Considerations

Filter #1: Primary filter -

Filter cel type of Pre-filter

Filter #2: Gas Filter –

Carbon filter designed in a honeycomb structure filled with treated activated carbon with high-grade absorption value. This filter has a high rate and high absorption capacity to trap the pollutants. These filters also help in increasing the life of next-stage HEPA filters. The specially treated carbon filter traps particulates such as VOC, Odour/ Foul Smell, gases such as oxides of Sulphide Sox, Formaldehyde, Hydrocarbons and Hydrogen Sulphide H_2S.

Filter #3: Dust Filter –

HEPA Filter - The Anti-bacterial coated HEPA filters have been developed with a superior Japanese technology that helps in trapping PM 2.5 SPM (suspended particulate matter), which are as small as 0.3 microns and have an efficiency of trapping 99% of the contaminants. HEPA filters also trap carcinogens such as PM 2.5 particulates, pollens, allergens, mold and fine dust and cigarette smoke.

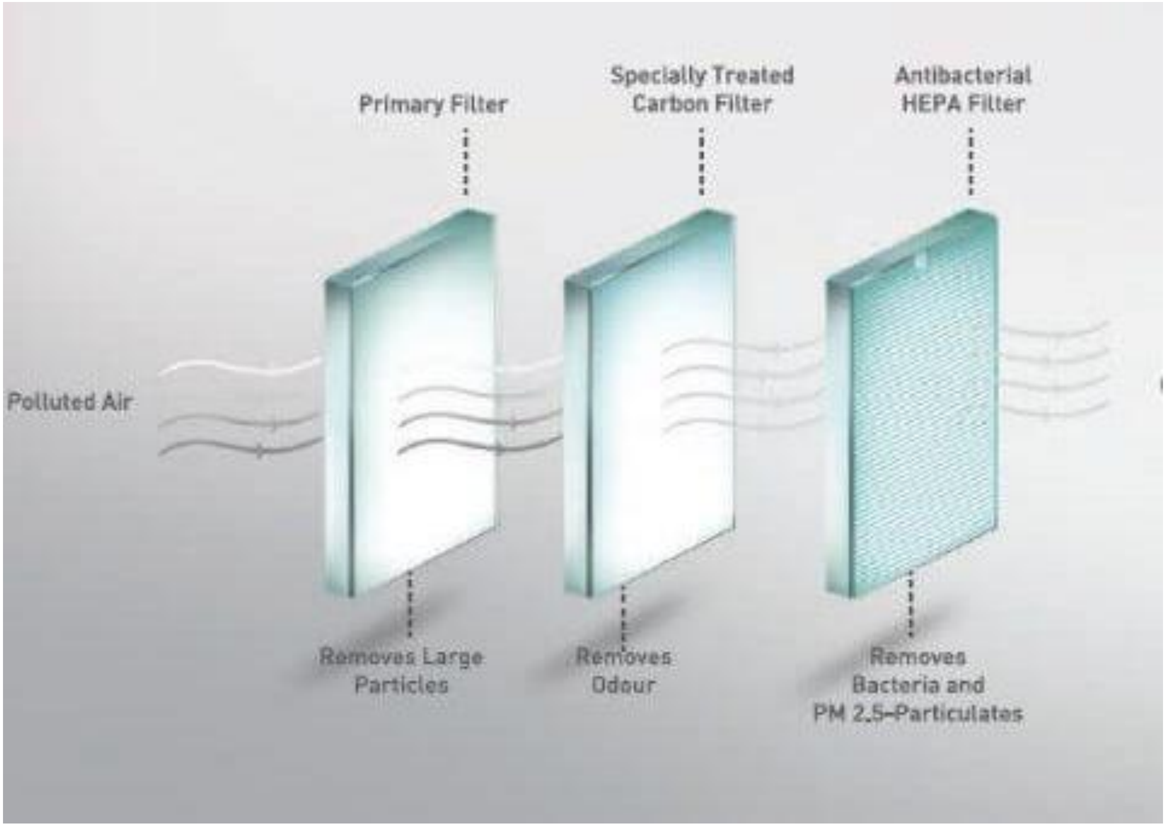

Fig 9. Levels of filtration

4.4 Air purifier Body Design

The purifier body can be made up of galvanized steel/iron, copper or by the use of metal alloys. Metal alloys, far exceed the performance specifications of their respective parent materials and are thus widely used.

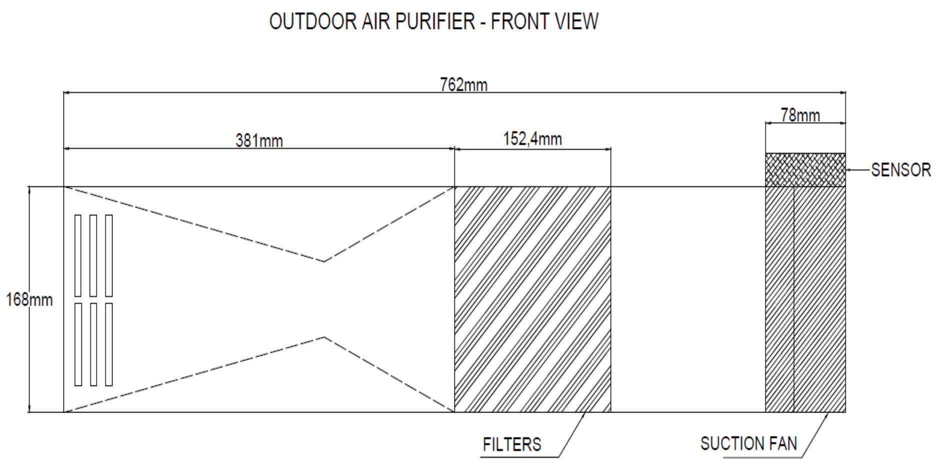

Fig 10. Air purifier Structural Design -Front View

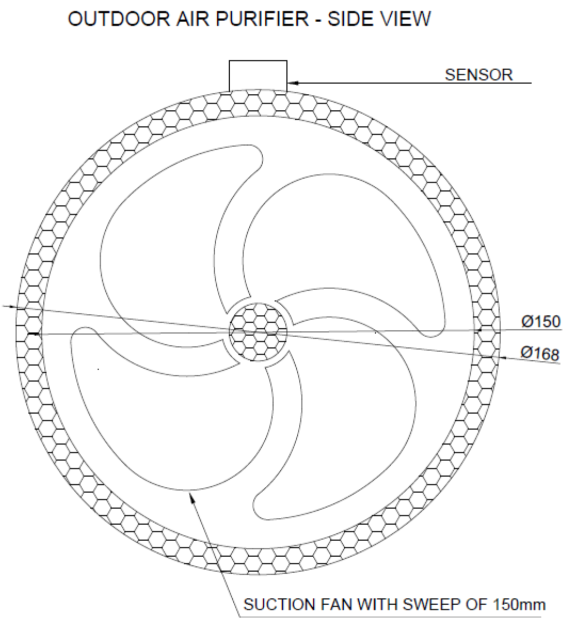

Fig11. Side view 1

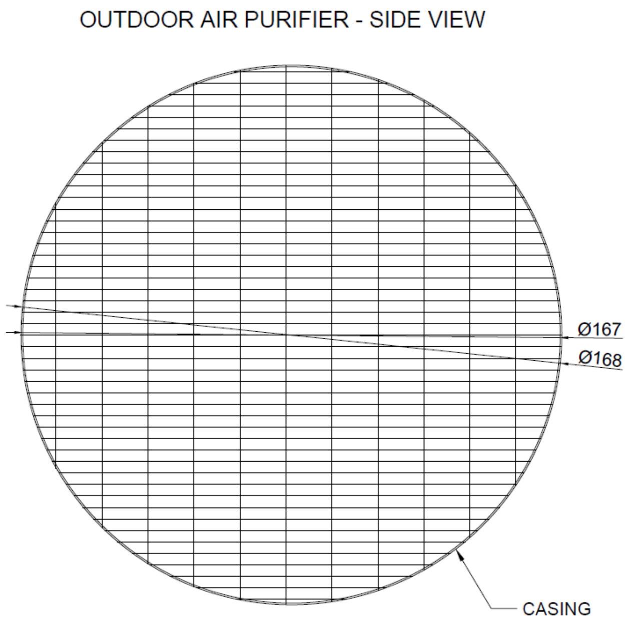

Fig12. Side view 2

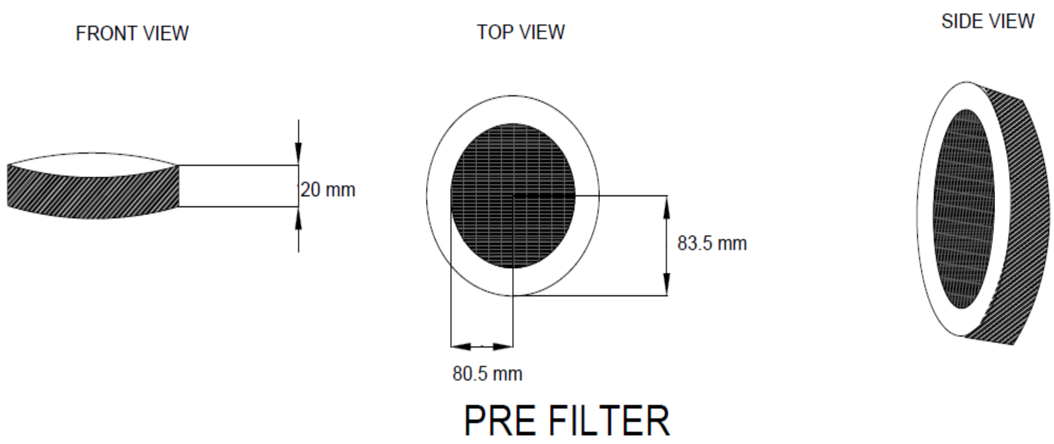

Fig.13 Front, top and side view of pre-filter

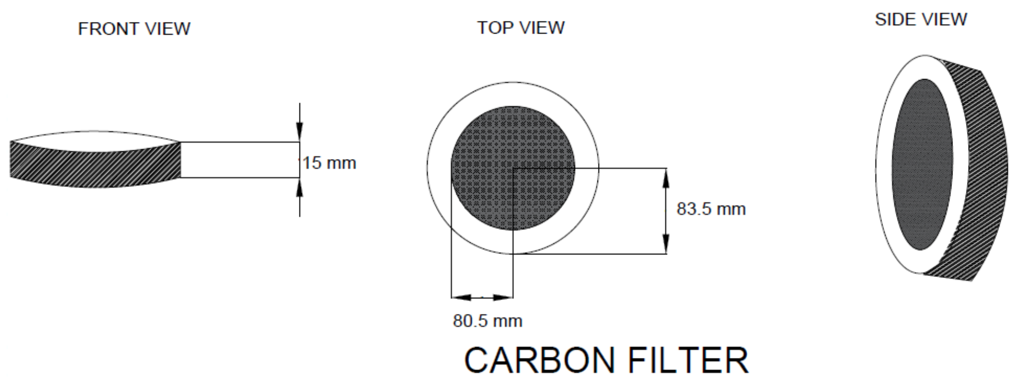

Fig.14 Front, top and side view of carbon filter

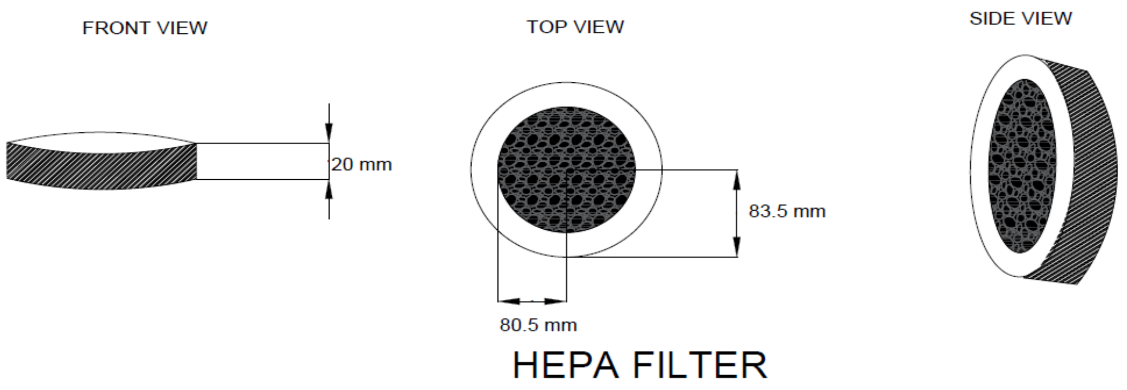

Fig.15 Front, top and side view of HEPA filter

CHAPTER 5: RESULTS AND FUTURE DIRECTIONS

- A theoretical outdoor air purifier design has been established keeping in consideration various factors such as volume, pressure, velocity, design of fan, filters and purifier body along with an Iot based monitoring system that not only indicates the level of pollution but also operates the air purifier when the degree of pollution rises over a threshold value.

- The outdoor air purifier designed can be conveniently installed under advertising billboards and hoardings and thus do not require any additional infrastructure.

Fig16. Installation under billboard

- Materials selected are cost efficient, widely available and require less maintenance.

- Application of work:

  1. Roadside pollution monitoring and control – At junctions and traffic signals.
  2. Industrial pollution monitoring and control
  3. Indoor Air Quality monitoring and control for large spaces.

  In all the cases, a danger limit is set that'll inform authorities to take actions if the air quality deterioration crosses the threshold value.

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