A Minor Project Report

On

**IOt BAsed**

**air quality monitoring system**

SUBMITTED IN PARTIAL FULFILLMENT FOR THE AWARD OF DEGREE OF

**Bachelor of Technology**

**IN**

**Electronics and Communication Engineering**



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**CERTIFICATE**

This is to certify that the minor project report entitled, “**IOT BASED AIR QUALITY MONITORING SYSTEM**” submitted by **VIPUL PAHUJA [9917102206], PREETIKA GUPTA[9917102250], RISHABH JAIN[9917102223]** in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in **Electronics and Communication Engineering** of the Jaypee Institute of Information Technology, Noida is an authentic work carried out by them under my supervision and guidance. The matter embodied in this report is original and has not been submitted for the award of any other degree.

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**DECLARATION**

We hereby declare that this written submission represents our own ideas in our own words and where others’ ideas or words have been included, have been adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission.

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**ABSTRACT**

Air pollution is the worst environmental problem and it causes a multitude of adverse effects on human health, water bodies and climate. The main source of air pollution in all major cities is due to vehicles and the second major source remains the industries.

Continued exposure to environments with poor air quality is a major public health concern in developed and developing countries. It has resulted in other respiratory problems like asthma attacks and skin rashes. The pollutants which spoil the air are invisible which has led to the negligence of the people. So, public acknowledgment is the prime requisite of today.

Hence the proposed system solves this major issue. The air pollution monitoring system is installed in a particular area where there are traces of acute air pollution to detect the constituent gases of air which may lead to harmful effects on human health and other living beings This system uses ESP32 and several gas sensors to predict the level of various harmful gases and particulate matter.

Significantly, around 1 million of deaths are due to polluted indoor air, and it is suggested that poor indoor air quality may pose a significant health risk to more than half of the world’s population. Due to its link with industrialization, societal health problems associated with poor air quality disproportionately affects developed and developing nations – it is estimated that air pollution is responsible for the premature deaths. Remedial action to improve air quality is often easy to implement once airborne pollutants have been detected.

This project provides a combination of the process of sensing several gas levels in the air and also the ambient temperature and humidity. The levels of the gases and the temperature are displayed on a platform named Thingspeakplatform, which continuously shows the real-time graphs of output values of the gas sensor, temperature and humidity sensor.

**ACKNOWLEDEMENT**

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**ABBREVIATIONS**

* LPG: Liquefied Petroleum Gas
* SDG: Sustainable Development Goals
* UN: United Nations
* AQI: Air Quality Index
* AQHI: Air Quality Health Index
* GUI: Graphical User Interface
* GPIO: General-Purpose input/output
* PCB: Printed circuit board
* HTML: Hypertext Markup Language
* PHP: Personal Home Page
* API: Application Programming Interface
* IDE: Integrated development environment
* HTTP: Hypertext Transfer Protocol
* PPM: Parts Per million

CHAPTER 1

INTRODUCTION

Monitoring air quality is essential for local authorities as well as for major public and private industries to understand and prevent air pollution and assess emission sources, in order to preserve health and contribute to the fight against the greenhouse effect.

It is facilitated to measure temperature, humidity, other weather parameters, concentration of air pollutants (such as SO2, NOx, CO, O3, THC etc), and particulate matters continuously all year round.

The measured data can be remotely monitored and exported in various formats to the local central authorities. The data can be published via the Internet for easy public access to raise awareness on current air pollution levels. This way, the public can prevent outdoor activities and reduce health impacts during heavy polluted days.

* 1. OVERVIEW

Ambient air monitoring is an integral part of an effective air quality management system. Reasons to collect such data include:

1. project provides a combination of process of sensing several gas levels in the air and also the temperature and humidity, thus sensing the quality of air.
2. assess the extent of pollution;
3. provide air pollution data to the general public in a timely manner;
4. provide information on air quality trends;
5. provide data for the evaluation of air quality models; and
6. support research (e.g., long-term studies of the health effects of air pollution).
7. project provides a combination of process of sensing several gas levels in the air and also the temperature and humidity, thus sensing the quality of air.
   1. OBJECTIVES
8. To measure and display temperature and humidity level of the environment.
9. To detect the presence of PM particles (2.5 or 10) in the environment.
10. To display the sensed data in user friendly On Thingspeak platform.
11. To combine advanced technologies to produce an air quality sensing system withAdvanced capabilities to provide low cost comprehensive monitoring.

1.3 LITERATURE SURVEY

Pollution is increasing in an alarming rate every day. Air is the most sensitive element of the environment which is polluted momentarily by the elements emitted to air. To knowthelevel of air pollution and air quality, this proposed system is a wireless sensor network that works mainly monitoring the pollution happening in a smart city. It is a low budget monitoring system with cheap but efficient sensors.

Some previous works like Smart environment monitoring system on vehicles was introduced on 2015. It basically figured out the emission rate of poisonous gasses which are responsible for air pollution. Industrial air pollution monitoring system for safety and health enhancement was introduced to know the hazardous gasses and their impact. Low cost air quality system was discussed on 2008 as because at that time the sensors were quite expensive. By using mobile GPRS system air pollution could be detected, Wireless sensor networkbased pollution monitoring system in metropolitan cities was introduced to know the air quality Pollution Dynamic Monitoring System.

By reviewing the future researches which has been done before, we can say that air pollution has increased in an alarming rate. If it is not stopped immediately the whole world is going to face a filthy and extreme weather for the future. There are more pollutions e.g. water pollution, noise pollution, plastic pollution, soil contamination but from the future studies we can say that air pollution is the most alarming issue and this should be studied for the sake of saving the world.

According to World Health Organization: WHO[1], from smog hanging over cities to smoke inside the home, air pollution poses a major threat to health and climate. The combined effects of ambient (outdoor) and household air pollution cause about 7 million premature deaths every year, largely as a result of increased mortality from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections. More than 80% of people living in urban areas that monitor air pollution are exposed to air quality levels that exceed the WHOguideline level of 10µg/m3, with low and middle-income countries suffering from the highest exposures.

The major outdoor pollution sources include vehicles, power generation, building heating systems, agriculture/waste incineration and industry. In addition, more than 3 billion people worldwide rely on polluting technologies and fuels (including biomass, coal and kerosene) for household cooking, heating and lighting, releasing smoke into the home and leaching pollutants outdoors. From 9 out of 10 people worldwide breathe polluted air.

CHAPTER 2

PROPOSED MODEL

The Proposed model of the system is as follows. Fig. 2.1 shows how the whole system will work. The block diagram of the system is showing that for a particular area selected how will it work. The device will be set up to take the environmental data and there will be a base standard value. The device will collect data and based on the set values it will show the output.



Fig. 2.1 PROPOSED MODEL OF SYSTEM

Source:- <https://www.mdpi.com/2076-3417/9/9/1831>

2.1 FLOWCHART OF SYSTEM

The flowchart as shown in Fig.2.2 is representing the step in which we are executing the project and the steps involved are shown in the flowchart below.

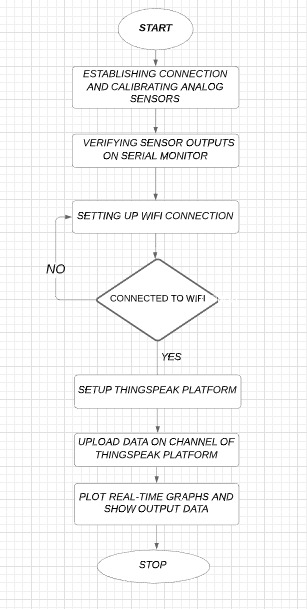


Fig. 2.2 FLOWCHART OF SYSTEM

* 1. COMPONENTS:-

It is a device that takes data from the environment that has been selected for our research purpose. The device is built with various sensors and they take data by sensing from the environment. The sensors take data from the environment and then the data is sent to the server where all the data is stored. This device is consisting of the following components:

* ESP32S Wroom
* DHT11 Sensor
* MQ135 Sensor
* SDS011 Sensor
* Thingspeak IOT Platform
* Breadboard
* Jumper Wires

2.2.1 ESP 32 WROOM

* It is a low-power microcontroller (MCU) with integrated Wi-Fi and dual-mode Bluetooth[2] as shown in Fig 2.3 — it is a successor of ESP8266 MCU.
* Arduino IDE is used to upload the sketch to ESP32Wroom.
* Pin diagram is shown in Fig 2.4

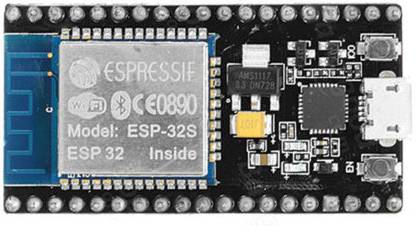


Fig 2.3 ESP32 WROOM

Source:-[https://www.google.com/search?q=esp32+wroom&sxsrf=ACYBGNTyNrPpygwAY4uwCgA- q6cnZQCVnw:1574263318971&source=lnms&tbm=isch&sa=X&ved=2ahUKEwi50aPvi\_nlAhUHQI8KHeiFBe0Q\_AUoAXoECA4QAw#imgrc=CZXqvopd7yCHVM](https://www.google.com/search?q=esp32+wroom&sxsrf=ACYBGNTyNrPpygwAY4uwCgA-%20q6cnZQCVnw:1574263318971&source=lnms&tbm=isch&sa=X&ved=2ahUKEwi50aPvi_nlAhUHQI8KHeiFBe0Q_AUoAXoECA4QAw#imgrc=CZXqvopd7yCHVM)[:](https://www.google.com/search?q=esp32+wroom&sxsrf=ACYBGNTyNrPpygwAY4uwCgA-q6cnZQCVnw:1574263318971&source=lnms&tbm=isch&sa=X&ved=2ahUKEwi50aPvi_nlAhUHQI8KHeiFBe0Q_AUoAXoECA4QAw)

****

Fig 2.4 PIN DESCRIPTION OF ESP32 WROOM

Source:- https://circuits4you.com/2018/12/31/esp32-devkit-esp32-wroom-gpio-pinout/

2.2.2 DHT11:-

* The DHT11 is a basic, low-cost digital temperature and humidity sensor as shown in Fig 2.5
* It uses a capacitive humidity sensor and a thermistor to measure the surrounding air and spits out a digital signal on the data pin[3].
* Pindescription is shown in Fig 2.6



Fig. 2.5 DHT11 SENSOR

Source:- <https://components101.com/dht11-temperature-sensor>

****

Fig 2.6 PIN DESCRIPTION OF DHT11 SENSOR

Source:- <https://components101.com/dht11-temperature-sensor>

2.2.3 MQ135 :-

* Air quality sensor for detecting a wide range of gases, including NH3, NOx, alcohol, benzene, smoke and CO2.(see Fig 2.7)
* It has high sensitivity to Ammonia, Sulfide and Benze steam, also sensitive to smoke and other harmful gases[4].
* Pin description is shown in Fig 2.8



Fig. 2.7MQ135 SENSOR

Source:- <https://robu.in/product/mq-135-air-quality-detector-sensor-module-arduino/>

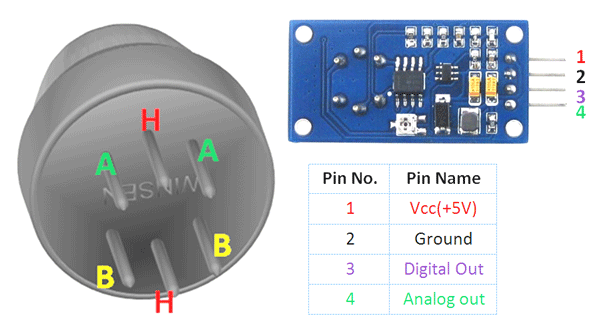
****

Fig 2.8 PIN DESCRIPTION OF MQ135

Source:-<https://iotdesignpro.com/projects/iot-based-air-quality-monitoring-system-with-twitter-notification>

2.2.4 SDS011:-

* Nova dust sensor SDS011 (Fig 2.9) is one of the best particulate sensors in terms of size, accuracy and price[5].
* It has a UART interface and measurement resolution of 0.3µg/m3. Operating voltage is 5V.
* Pin description is shown in Table 2.1



Fig. 2.9SDS011 SENSOR

Source:- <https://www.tinytronics.nl/shop/en/sensors/temperature-air-humidity/nova-sds011-high-precision-laser-dust-sensor>

Table 2.1 PIN DESCRIPTION OF SDS011

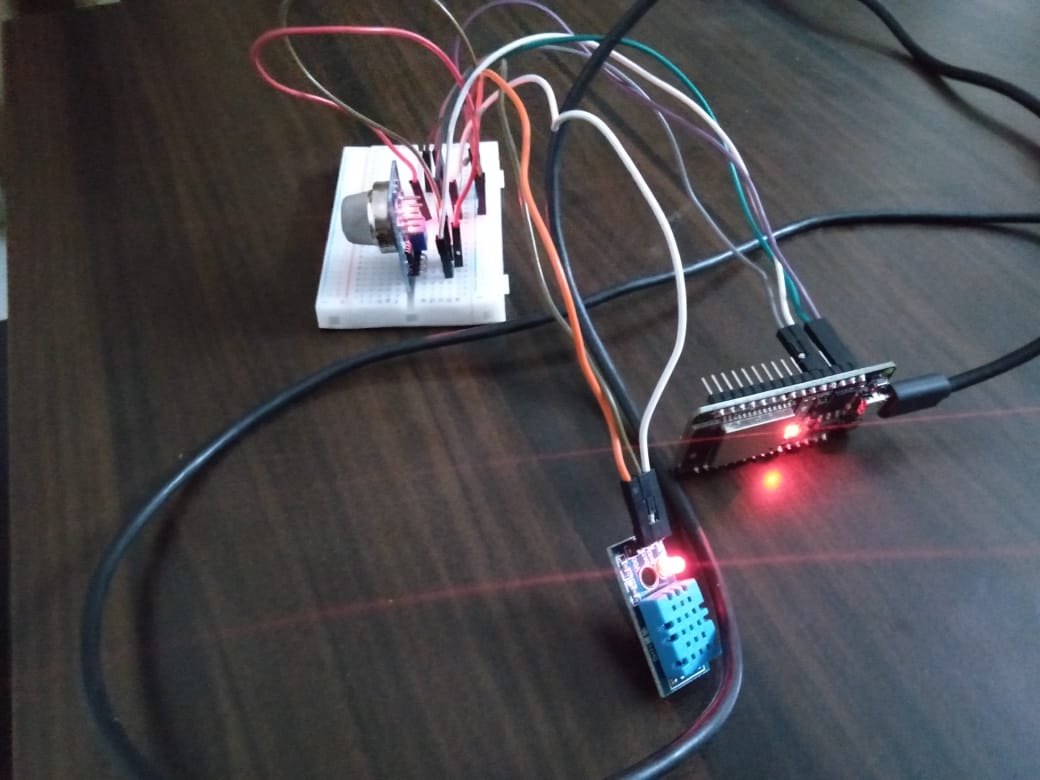
|  |  |
| --- | --- |
| ESP32 | SDS011 |
| 5V | Vin/5V |
| GND | GND |
| TX | RX2(D16) |
| RX | TX2(D17) |

Source:- <https://blog.jokielowie.com/en/2017/10/esp-32-sds011-smog-quick-wifi-sensor/>

* + 1. THINGSPEAK:-
* The project is based on ThingSpeak cloud computing. ThingSpeak is an open source IOT application and API to store and retrieve data from things using HTTP protocol over the Internet via LAN.
* It enables the creation of sensor-logging applications, location-tracking applications and a social network of things with status updates.

2. 3 CONNECTIONS :-

2.3.1 CONNECTION OF DHT11, MQ135 and SDS011 WITH ESP32 (Fig 2.10)



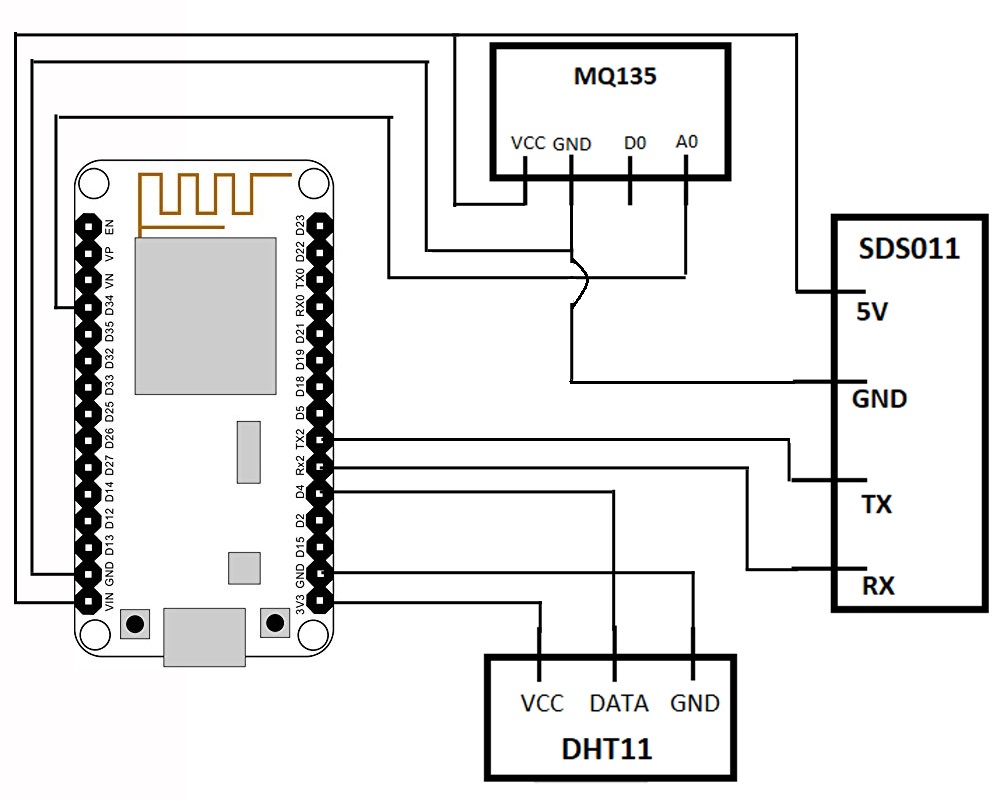
****

Fig 2.10 Connection of DHT11, MQ135 and SDS011 with ESP32

2.3.2 OUTPUT ON THINGSPEAK PLATFORM

The output as shown in Fig. 2.11 is the output on Thingspeak Platform which shows values of temperature, humidity and gas concentrations at certain intervals of time in a day. It also provides with fixed values at certain point of time. Based on the collection of these values, various graphs are plotted by the platform depicting the trend followed by parameters like temperature and humidity. The concentration of harmful gases is also shown in the figure.

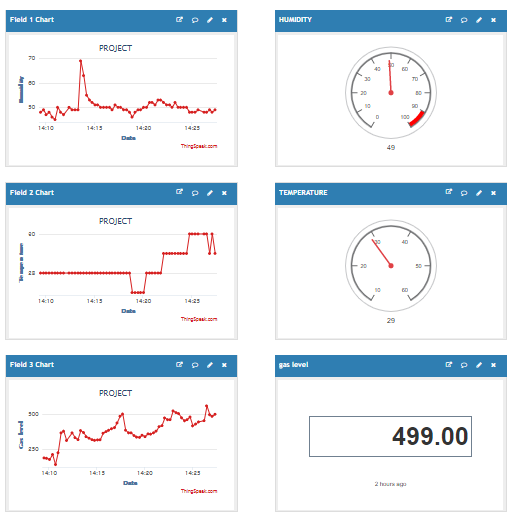


Fig 2.11 Output ofthingspeak

CHAPTER 3

AIR QUALITY MONITORING AND ITS IMPORTANCE

Air Quality monitoring is a method to measure ambient pollution levels in an area. The collected data will indicate the status of the quality of air we breathe.

The data, over a long term, allows us to tease out patterns that help support air pollution control policy. These patterns include, spatial differences in pollution (which areas of the city are more polluted) and temporal differences (is there a pattern of pollution levels during a day and/or a year).

So, while air pollution monitoring itself does not reduce air pollution, it gives us clues on how much is the pollution, where is the pollution, and when is that pollution. It also help officials to focus on areas with maximum pollution. It can also create awareness among citizens about poor air quality and urge them to minimise pollution.

Using the data trends, we can conclude if our efforts for improving the quality of air are successful and by how much. If not, do we need to try other options or be more aggressive in our current efforts.

3.1 AIR QUALITY INDEX AND SAFETY LEVELS

The AQI[6]is an index for reporting daily air quality. It is used by government agencies to communicate with the public about how polluted the air currently is or how polluted it is forecast to become. The AQI focuses on health effects you may experience within a few hours or days after breathing polluted air. Public health risks increase as the AQI rises. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act:

* Ground-level ozone
* Particle pollution (also known as particulate matter)
* Carbon monoxide,
* Sulphur dioxide
* Nitrogen dioxide.

For each of these pollutants, EPA has established national air quality standards to protect public health .Ground-level ozone and airborne particles are the two pollutants that pose the greatest threat to human health.

Different countries have their own air quality indices, corresponding to different national air quality standards. Some of these are the [Air Quality Health Index (Canada)](https://en.wikipedia.org/wiki/Air_Quality_Health_Index_(Canada)), the [Air Pollution Index](https://en.wikipedia.org/wiki/Air_Pollution_Index) (Malaysia), and the [Pollutant Standards Index](https://en.wikipedia.org/wiki/Pollutant_Standards_Index) (Singapore).

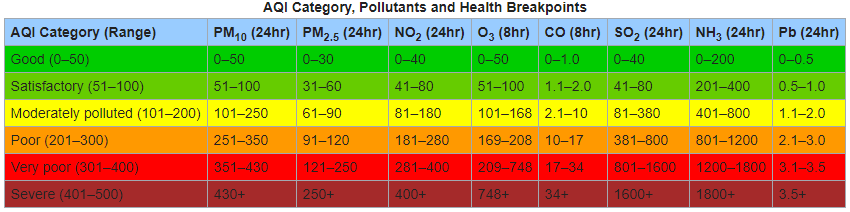
3.1.1AIR QUALITY INDEX(INDIA)

The National Air Quality Index (AQI) was launched in New Delhi on September 17, 2014, under the Swachh Bharat Abhiyaan.

TheCentral pollution control board along with State Pollution Control Boards has been operating National Air Monitoring Program (NAMP) covering 240 cities of the country having more than 342 monitoring stations. .The continuous monitoring systems that provide data on near real-time basis are installed in New Delhi, Mumbai, Pune and Ahmedabad.

There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The proposed AQI will consider eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb) for which short-term National Ambient Air Quality Standards are prescribed. The AQI values and corresponding concentrations as well as associated likely health impacts for the identified eight pollutants are shown in Table 3.1

Table 3.1 AQI CONCENTRATIONS AND HEALTH IMPACTS



Source:-<http://blogs.law.columbia.edu/climatechange/2016/07/18/energy-and-air-pollution-a-new-report-from-the-international-energy-agency/>

3.2 AIR QUALITY INDEX IN DIFFERENT COUNTRIES

3.2.1 AIR QUALITY HEALTH INDEX (CANADA)

Air quality in Canada has been reported for many years with provincial Air Quality Indices (AQIs). Significantly, AQI values reflect air quality management objectives, which are based on the lowest achievable emissions rate, rather than exclusive concern for human health. The [Air Quality Health Index](https://en.wikipedia.org/wiki/Air_Quality_Health_Index_(Canada)) or (AQHI) is a scale designed to help understand the impact of air quality on health. It is a health protection tool used to make decisions to reduce short-term exposure to air pollution by adjusting activity levels during increased levels of air pollution.The Air Quality Health Index provides a number from 1 to 10+ to indicate the level of health risk associated with local air quality. On occasion, when the amount of air pollution is abnormally high, the number may exceed 10 as shown in Fig 3.1.

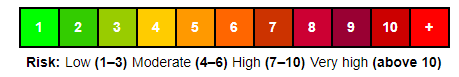


Fig 3.1 Air quality health index of Canada

Source:-https://en.wikipedia.org/wiki/Air\_quality

3.2.2 POLLUTANT STANDARDS INDEX (SINGAPORE)

[Singapore](https://en.wikipedia.org/wiki/Singapore)uses the [Pollutant Standards Index](https://en.wikipedia.org/wiki/Pollutant_Standards_Index)to report on its air quality,with details of the calculation similar but not identical to those used in Malaysia and Hong Kong.The PSI chart below is grouped by index values and descriptors, according to the [National Environment Agency](https://en.wikipedia.org/wiki/National_Environment_Agency) and is shown in the Table 3.2 below

Table 3.2 AIR QUALITY CLASSIFICATION

|  |  |
| --- | --- |
| PSI | AIR QUALITY DESCRIPTOR |
| 0-50 | GOOD |
| 51-100 | MODERATE |
| 101-200 | UNHEALTHY |
| 201-300 | VERY UNHEALTHY |
| 301AND ABOVE | HAZARDOUS |

3.3 AIR QUALITY INDEX CALCULATION

The air quality index is a [piecewise linear function](https://en.wikipedia.org/wiki/Piecewise_linear_function)of the pollutant concentration. At the boundary between AQI categories, there is a discontinuous jump of one AQI unit. To convert from concentration to AQI this equation is used .Example is shown in Table 3.3

****where,

I=AQI

C = the pollutant concentration,

C low= the concentration breakpoint that is < C

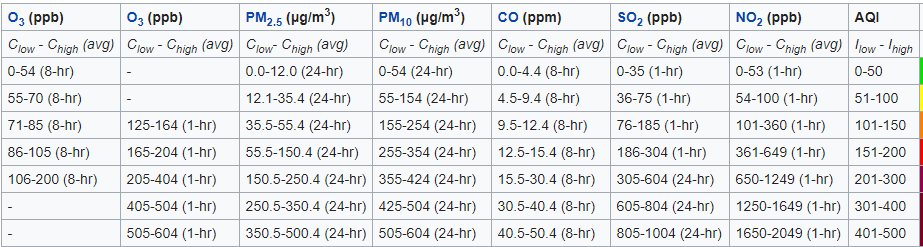
C high = the concentration breakpoint that is ≥ C

I low = the index breakpoint corresponding to C low

I high  = the index breakpoint corresponding to C high

Table 3.3PM PARTICLES RESOLUTION

For example:



Source: <https://www.airparif.asso.fr/en/reglementation/indice-qualite-air-europeen>

Suppose a monitor records a 24-hour average fine particle (PM2.5) concentration of 12.0 micrograms per cubic meter. The equation above results in an AQI of:

CHAPTER 4

PROGRAMMING

4.1 DHT11:-

We have used adafruit sensor and dht library in the code[7]

#include <Adafruit\_Sensor.h>

#include <dht.h>

dht DHT;

intsensorPin = 4;

void setup(){

Serial.begin(9600);

delay(500);//Delay to let system boot

pinMode(sensorPin,INPUT);

Serial.println("DHT11 Humidity & temperature Sensor\n\n");

}//end "setup()"

void loop(){//Start of Program

DHT.read11(dht\_apin);

Serial.print("Current humidity = ");

Serial.print(DHT.humidity);

Serial.print("% ");

Serial.print("temperature = ");

Serial.print(DHT.temperature);

Serial.println("C ");

delay(3500);//Wait 5 seconds before accessing sensor again.

}// end loop

4.2 MQ135:-

The value of MQ135 is scaled before taking output[8].

intgas\_sensor = 34; //Sensor pin

float m = -0.318; //Slope

float b = 1.133; //Y-Intercept

float R0 = 18.14; //Sensor Resistance in fresh air from calibration

void setup() {

Serial.begin(115200); //Baud rate

pinMode(gas\_sensor, INPUT); //Set gas sensor as input

}

void loop() {

float sensor\_volt; //Define variable for sensor voltage

float RS\_gas; //Define variable for sensor resistance

float ratio; //Define variable for ratio

float sensorValue = analogRead(gas\_sensor); //Read analog values of sensor

sensor\_volt = sensorValue\*(5.0/4095.0); //Convert analog values to voltage

RS\_gas = ((5.0\*10.0)/sensor\_volt)-10.0; //Get value of RS in a gas

ratio = RS\_gas/R0; // Get ratio RS\_gas/RS\_air

double ppm\_log = (log10(ratio)-b)/m; //Get ppm value in linear scale

double ppm = pow(10, ppm\_log); //Convert ppm value to log scale

Serial.println(sensorValue);

Serial.print("sensor\_volt");

Serial.print("ppm");

Serial.println(ppm);

delay(3000);

}

4.3 SDS011

#include <Ticker.h>

#include <AsyncMqttClient.h>

#include <SDS011.h>

const char SSID[] = "My\_WiFi";

const char PASS[] = "My\_Pass";

constIPAddress BROKER = {192, 168, 1, 10};

SDS011 sds011;

AsyncMqttClientmqttClient;

Ticker mqttReconnectTimer;

WiFiEventHandlerwifiConnectHandler;

WiFiEventHandlerwifiDisconnectHandler;

Ticker wifiReconnectTimer;

bool connected = false;

void connectToWifi() {

WiFi.begin(SSID, PASS);

}

void onWifiConnect(constWiFiEventStationModeGotIP& event) {

connectToMqtt();

}

void onWifiDisconnect(constWiFiEventStationModeDisconnected& event) {

mqttReconnectTimer.detach(); // ensure we don't reconnect to MQTT while reconnecting to Wi-Fi

wifiReconnectTimer.once(2, connectToWifi);

}

void connectToMqtt() {

mqttClient.connect();

}

void onMqttConnected(bool sessionPresent) {

connected = true;

}

void onMqttDisconnect(AsyncMqttClientDisconnectReason reason) {

connected = false;

if (WiFi.isConnected()) {

mqttReconnectTimer.once(2, connectToMqtt);

}

}

void setup() {

wifiConnectHandler = WiFi.onStationModeGotIP(onWifiConnect);

wifiDisconnectHandler= WiFi.onStationModeDisconnected(onWifiDisconnect);

mqttClient.onConnect(onMqttConnected);

mqttClient.onDisconnect(onMqttDisconnect);

mqttClient.setServer(BROKER, 1883);

sds011.setup(&Serial);

sds011.onData([](float pm25Value, float pm10Value) {

if (connected) {

mqttClient.publish("/SENSOR/PM2\_5",1,false,String(pm25Value, 1).c\_str());

mqttClient.publish("/SENSOR/PM10",1, false, String(pm10Value, 1).c\_str());

}

});

sds011.onResponse([](){

// command has been executed

});

sds011.onError([](int8\_t error){

// error happened

// -1: CRC error

});

sds011.setWorkingPeriod(5);

connectToWifi();

}

void loop() {

sds011.loop();

}

4.4 THINGSPEAK

We will be including the WiFi and thingspeak library for Arduino IDE[9].

#include <ETH.h>

#include <WiFi.h>

#include <WiFiAP.h>

#include <WiFiClient.h>

#include <WiFiGeneric.h>

#include <WiFiMulti.h>

#include <WiFiScan.h>

#include <WiFiServer.h>

#include <WiFiSTA.h>

#include <WiFiType.h>

#include <WiFiUdp.h>

#include <ThingSpeak.h>

#include <DHTesp.h>

#include <Adafruit\_Sensor.h>

#include <dht.h>

#define dht\_apin 4 // Analog Pin sensor is connected to

dht DHT;

const char\* ssid = "Realme 2";

const char\* password = "11111111";

char thingSpeakAddress[] = "api.thingspeak.com";//ThingSpeak Settings

String writeAPIKey = "HF4I5C0ELVJ11F3B";

intsensorValue = 0;

intsensorPin = 34;

float m = -0.318; //Slope

float b = 1.133; //Y-Intercept

float R0 = 11.820; //Sensor Resistance in fresh air from previous code

float sensor\_volt; //Define variable for sensor voltage

float RS\_gas; //Define variable for sensor resistance

float ratio; //Define variable for ratio

void setup(){

Serial.begin(115200);

delay(500);//Delay to let system boot

pinMode(sensorPin,INPUT);

Serial.println("DHT11 Humidity & temperature Sensor\n\n");

delay(1000);//Wait before accessing Sensor

WiFi.begin(ssid, password);

Serial.println("Time to connect to WiFI:");

while (WiFi.status() != WL\_CONNECTED) {

delay(500);

Serial.print("."); }

Serial.print("connected");

}//end "setup()"

void loop(){

//Start of Program

float sensorValue = analogRead(sensorPin); //Read analog values of sensor

sensor\_volt = sensorValue\*(5.0/4095); //Convert analog values to voltage

RS\_gas = ((5.0\*10.0)/sensor\_volt)-10.0; //Get value of RS in a gas

ratio = (RS\_gas/R0); // Get ratio RS\_gas/RS\_air

double ppm\_log = (log10(ratio)-b)/m; //Get ppm value in linear scale

double ppm = pow(10, ppm\_log); //Convert ppm value to log scale

Serial.print("AirQuaity=");

Serial.println(sensorValue);

Serial.println(ppm);

DHT.read11(dht\_apin);

float hum=DHT.humidity;

float temp=DHT.temperature;

Serial.print("Current humidity = ");

Serial.print(hum);

Serial.print("% ");

Serial.print("temperature = ");

Serial.print(temp);

Serial.println("C ");

UpdateThingSpeak(hum,temp,sensorValue);

delay(16000);//Wait 16 seconds before accessing sensor again.

}// end loop

void UpdateThingSpeak(float hum, float temp ,floatsensorValue) {

WiFiClient client;

String url = "GET /update?api\_key=" + writeAPIKey + "&field1=" + String(hu,1) +

"&field2=" + String(te,1) +

"&field3=" + String(sensorValue,1) +

" HTTP/1.1";

if (client.connect(thingSpeakAddress, 80))

{client.println(url);

client.println("Host: api.thingspeak.com");

client.println("Connection: close\n");

Serial.println("Upload of data complete");

if (client.connected())

Serial.println("Connecting to ThingSpeak...");

else

Serial.println("Connection to ThingSpeak failed");

}

else

{

Serial.println("Connection to ThingSpeak Failed");

}

delay(60000); // Essential to enable upload to complete

client.stop(); // close the connection}

CHAPTER 5

EXPERIMENTAL RESULTS AND ANALYSIS

5.1 EXPERIMENTAL RESULTS

We have successfully calibrated and connected MQ135, DHT11 and SDS011 sensor with ESP32 Node MCU. Data from sensors is collected at certain intervals and it is uploaded using Wi-Fi on the IOT based platform Thingspeak as shown in Fig. 5.1. It uses math modelling to plot graphs and provide a better way of Data Visualisation.

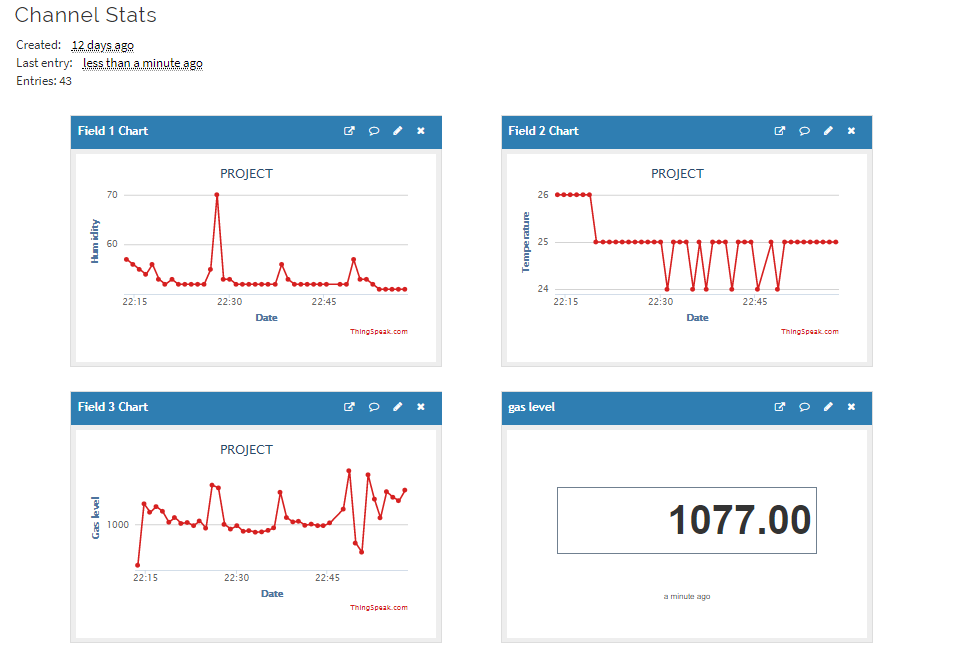


Fig 5.1 Output of Thingspeak platform

5.2 ANALYSIS

Output from various sensors is first displayed on serial monitor and then uploaded on the Thingspeak platform. Graphs are plotted in real time,that is live values are uploaded and plotted which helps in analysing the previous trends of temperature, humidity and harmful gas level in atmosphere.

CHAPTER -6

CONCLUSION AND FUTURE SCOPE:-

6.1 CONCLUSION

The integration of atmospheric sensors in wearable technology is set to become a major real-world application of the supposed 'internet of things', wherein all types of devices will be linked easily. The prospective gadgets would not only collect information and share it discretely to benefit a large section of society, but would also receive and interpret data with excellent precision, more superior to the current generation of smartphones.

The developed air quality monitoring and visualization system accurately detects the presence of pollutants like carbon monoxide, carbon dioxide, smoke and dust in atmosphere. Analogue sensors are calibrated so that they provide accurate values to the system. The present system has been integrated with IOT framework which has efficiently been used to measure and monitor the pollutants, temperature and humidity in real–time. The Thingspeak IOT platform not only measures and monitors the given parameters but also plots live graphs for better visualization of parameters. This system overcomes the problem of pollution monitoring, sustainability assessments and measurement of temperature and humidity. The data is automatically stored in the platform used and this information can be used by the authorities to take prompt actions. It also helps general public to have a better understanding about the amount of pollutants, change in temperature and humidity in their area and to take suitable measures to avoid dangerous levels.

6.2 FUTURE SCOPE

We all know that pollution is increasing very rapidly on our planet .Outdoor air pollution has grown 8% globally in the past five years, with billions of people around the world now exposed to dangerous air, [according to new data](http://www.who.int/phe) from more than 3,000 cities compiled by the World Health Organisation (WHO). Most of this pollution is due to industrialisation. This is a robust system which is very useful in industries as this system is user friendly and cost of the product is affordable. This system is monitoring on four parameters and hence can be expanded by considering more parameters that cause the pollution especially by the industries. Parameters can be selected on the basis of products that a particular industry manufactures. We can also create large datasets of these parameters in a particular area. It can be used to compare the levels of these parameters with safe levels.

With huge datasets, there is a possibility of forming greater variety of graphs which will help in visualization of data in a much better way. Box plots, Strip plots, violin plots can be plotted. It will also make way for Machine learning analysis and regression analysis to predict future levels of given parameters.

Many pollutants do not have sensors that sense them if available they are very expensive and hence building sensors for different parameters might be a future and very challenging task. The developed system consumes much power, so we can use solar power as an external source of energy in future and it will definitely improve the reliability of the system.

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