Bharati Vidyapeeth
Deemed to be University, Pune, India
College of Engineering

CSBS SEM-V
Mini Project

# AIR POLLUTION MONITORING SYSTEM

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***Submitted by:***

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# <u>Certificate</u>

This is to certify that **Devansh Verma, Ritish Kumar Singh, Siddhant Singh, and Sarthak Singh Rawat**, students of B.Tech. Computer Science and Business Systems Semester-5 have successfully completed a mini project on ***Air Pollution Monitoring System*** based on IoT under the guidance of **Prof. Trupti Suryawanshi** for the academic year 2021-2022.

**---------------------**                                **------------------------**

**HOD's Signature**                                **Teacher's Signature**

# ACKNOWLEDGEMENT

We would like to thank our project instructor guide **Prof. Trupti Suryawanshi** who gave us this opportunity to work on this project. We got to learn a lot from this project about the serious health and environmental issues which is caused by the Air Pollution and how can we tackle this problem to live a better and healthy lifestyle.

We are highly indebted to the faculty members of our college for their guidance and constant supervision by our instructor guide as well as for providing necessary information regarding the project & for their support in completing the project.

At last, we would like to extend my heartfelt thanks to my parents because without their help this project would not have been successful. Finally, we would like to thank my dear friends who have been with me all the time. Our thanks and appreciations also go to the people who have willingly helped me out with their abilities.

*Abstract*

Internet of Things (IoT) may be a worldwide system of “smart devices” which will sense and connect with their surroundings and interact with users and other systems. Global air pollution is one of the major concerns of our era. The level of pollution has increased with times by lot of things like the increase in population, increased vehicle use, industrialization and urbanization which ends up in harmful effects on human wellbeing by directly affecting health of population exposed to it. Air quality goes down when enough amount of harmful gases present in the air like carbon dioxide, smoke, alcohol, benzene, NH3, and NO2. In order to analyses we are developing an IOT Based pollution Monitoring System which we'll monitor the Air Quality over an internet server. Existing monitoring systems have inferior precision, low sensitivity, and need laboratory analysis. Therefore, improved monitoring systems are needed. To overcome the issues of existing systems, we propose a three-phase pollution monitoring system. It will show the air quality in PPM on the LCD and also on webpage in order that we will monitor it very easily. In this IOT project, you can monitor the pollution level from anywhere using your computer or mobile device. The system uses MQ2 and MQ7 sensor for monitoring Air Quality. It measures their amount exactly and finds out harmful gases.

*Key Words:* IoT, Smart Device, Pollution, Monitoring.

# Introduction

The Air Excellence Guide (AEG) may be a common indicator of air quality. The Air Quality Indicator (AQI) is calculated and supported on air pollutants like CO and NO2 compounds that consume opposing possessions happening the atmosphere and human health. The Air Quality Indicator may be a range that represents the very finest meditation of a specific air unused matter at a particular time. We propose an air quality as well as air pollution monitoring system that allows us to monitor and check live air quality as well as air pollution in an area through Internet of Things (IoT). It uses air sensors (Gas Sensor MQ135) to sense presence of harmful gases/compounds in the air and constantly transmit this data. In addition, system keeps measuring air level and reports it. The sensors interact with Arduino Uno (Microcontroller) which processes this data and transmits it over the application. This allows authorities to monitor air pollution in different areas and act against it. In addition, authorities can keep a watch on the air pollution near schools, and hospitals areas. Normally, little concentrations area unit measured exploitation ppb (parts per billion), that represents units of mass of a material per one billion units of total mass. Parts per million (ppm) may be similar and unremarkable used unit to measure concentrations of pollutants. It determines the requirements of a new system and analyze on product and resource requirement, which is required for the successful system. The product requirement contains input and output requirements it gives the wants in term of input to produce the required productivity. The resource requirements define in brief about the hardware that are needed to achieve the required functionality. In this project we are going to make an IoT based Air Pollution Detection Monitoring System in which I monitor the Air Quality over a web server using ESP8266 Wi-Fi device and a trigger alarm when the air quality goes down a certain level means when there is amount of harmful gases is present in the air like $CO_2$. It shows the air quality in PPM (Parts Per Million) on LCD and webpage so that we can monitor it very easily.

**Purpose of Project**

The project is an implementation of IoT (Internet of Things) Based Air Pollution Monitoring System Using Arduino. Air pollution is a growing issue and it is necessary to monitor air quality for a better future and healthy living for all. IoT is getting popular day-by-day and standards are on its way. Therefore, collection of air quality information is easier. Analysis of monitoring data allows us to assess how bad air pollution from day to day. Thus because of this expansion in the quantity of vehicles contamination is developing quickly and it influencing people groups wellbeing too. This air contamination makes disease and harm safe, neurological, regenerative and respiratory framework. In extraordinary cases, it can likewise cause passing. As indicated by overview 50000 to 100000 unexpected losses occurred to us only because of air contamination. Along these lines, there is a requirement for checking air quality and to monitor it. IoT is the system of physical gadgets, vehicles, home apparatuses, and different things implanted with hardware, programming, sensors, and availability which empowers these articles to associate and trade information. IoT permits articles to be noticed or controlled.

**Objectives of Monitoring Air Quality**

The air quality monitoring program design dependent upon the monitoring specific objectives specified for the air quality management in the selected area of interest. Defining the output influence, the design of the network and optimize the resources used for monitoring. It also ensures that the network is specially designed to optimize the information on the problems at hand. There might be different objectives for the development of the environmental monitoring and surveillance system. Normally, the system has to provide on-line data and information transfer with a direct /automatically/ on-line quality control of the collected data. Several monitors, sensors and data collection systems to be applied to make on-line data handover and control likely. The main objectives stated for the development of an air quality measurement and surveillance program might be to facilitate the background concentration(s) measurements, monitor current levels as a baseline for assessment, check the air quality relative to standards or limit values, detect the importance of individual sources, enable comparison of the air quality data from different areas and countries, collect data for the air quality management, traffic and land-use planning purposes, observe trends (related to emissions), develop abatement strategies, determine the exposure and assess the effects of air pollution on health, vegetation or building materials, inform the public about the air quality and raise the awareness, develop warning systems for the prevention of undesired air pollution episodes, facilitate the source apportionment and identification, supply data for research investigations, develop/validate management tools (such as models), develop and test analytical instruments and to support legislation in relation to the air quality limit values and guidelines. The relationships between the data collected and the information to be derived from them must be taken into account when a monitoring program is planned, executed and reported. This emphasizes the need for users and potential users of the data to be involved in planning surveys, not only to ensure that the surveys are appropriate to their needs but also to justify committing the resources.

**Air Quality Parameters**

The important parameters that are considered in the proposed framework include:

Carbon Dioxide ($CO_2$) – $CO_2$ is colorless, odorless gas and non-combustible gas. Also, it is measured under the category of smother gases that have ability of interfering the availability of oxygen for tissues. Carbon Dioxide is a gas vital to life in the world, because it is one of the most vital elements evolving photosynthesis process, which converts solar into chemical energy. The concentration of $CO_2$ has amplified due mainly to massive remnant fuels boiling. This increase makes plants grow rapidly. The rapid growth of undesirable plants leads to the increase use of chemicals to eliminate them.

Sulphur Dioxide ($SO_2$) - Sulphur Dioxide is a colorless gas, detectable by the distinct odor and taste. Like $CO_2$, it is mainly due to fossil fuels boiling and to manufacturing processes. In high attentions may cause breathing problems, especially in sensitive groups, like asthmatics. It contributes to acid rains.

Nitrogen Dioxide ($NO_2$) – Nitrogen Dioxide is a brownish gas, easily detectable for its odor, very corrosive and highly oxidant. It is produced as the result of fossil fuels burning. Frequently NO terrified to the atmosphere is converted in $NO_2$ by chemical processes. In high absorptions, $NO_2$ may principal to respiratory problems. Like $SO_2$, it contributes to acid rains. Smoke - About 1 million people are in custom of tobacco smoking globally of which majority population is from rising countries. Every year nearly 4.9 million people expired due to smoking allow to 2007 report. In addition, second hand smoke is serious threat to the health of people of all age's causes 41000 deaths each year.

LPG - Liquefied petroleum gas (LPG) is an odorless and colorless liquid which evaporates readily into a gas. Leakage is generally noticed by adding an odorant into it. It is considered 4 under the category of highly flammable gases and it can be classified as a carcinogen and mutagen if Butadiene content is more than 0.1%. LPG may escape in the form of a gas or a fluid. If it escapes in the form of a liquid, it vanishes quickly and will eventually form large cloud of gas in air, which is relatively thicker than air thus drops to the ground. Whereas, LPG vapors travel along the ground for a long distance and gets collected in drains or basements. Gas principals to burn or detonate after getting in touch with a source of ignition.

Temperature and humidity - Quantity of temperature is an important for safety of people and affects our life skills. Greenhouse outcome can be observed by measuring temperature and comparing temperature changes from historical to present time especially since the industrial revolution using climate data. Humidity is a type of gas that guards us from UV rays from the sun and helps trick heat on Earth, thereby making the climate on Earth, a pleasant one for living. However, as humidity increases, the warmth on Earth also increases which makes our life uncomfortable. Humidity is essential for various storage and food processing facilities.

**Importance of Air Pollution Monitoring System**

Air is one of the most basic and important elements for human being to survive. Clean and Sound air is the key to a good and healthy life. But now days in city life it has become the most threatened factor. Pollution of air has become the most concerned and affected issue now for us. A diversity of air pollutants has known or suspected injurious effects on human health and the atmosphere. In most areas, these toxins are principally the products of combustion from space warming, power generation or from motor vehicle traffic flow. Pollutants from these sources may not only prove a problem in the immediate locality of these sources but can travel long distances. Generally, if someone is young and in a good state of health, moderate air pollution levels are unlikely to have any serious short term effects. However, higher levels and long term exposure to air pollution can lead to more serious symptoms and conditions causing human health. This not only affects the respiratory and inflammatory response systems, but can also lead to more serious conditions such as heart disease and cancer. People with lung or heart situations to be more vulnerable to the effects of air pollution. Air pollution has also been recognized by doctors as one of the world's greatest 10 killers seeing some 29,000 premature deaths in UK and 430,000 worldwide in one year. Air pollution can cause both short term and long term effects on health and many people are concerned about pollution in the air that they breathe. These people may include:

- People with heart or lung situations, or other breathing problems, whose health to be exaggerated by air pollution.

- Parents, careers and healthcare professionals who look after someone whose health is sensitive to pollution.

- People who want to know more about air pollution, its causes, and what they can do to help reduce it. Monitoring air quality is essential for local authorities as well as for major public and private industries to understand and prevent air pollution and measure emission sources, in order to reserve health and donate to the fight against the greenhouse influence. Industrial operatives use air quality monitoring apparatus to cost effectively monitor and manage emanations on their perimeter, which helps them recover relationships with controllers and communities. With air quality rule shifting the burden from publicly funded monitoring to observing funded by industry, it has been progressively important for businesses to obtain their individual quality monitoring equipment. To get the best results from the environment about the pollution level of air, toxicity and harmfulness for human, air quality monitoring device is vastly used. An air quality monitor is an expedient that actions the level of common air toxins. Displays are available for both indoor and outdoor locations. Indoor air quality monitors are naturally sensor-based tools. Some of them are able to quantity ppb levels and come as either varied gas or moveable units. Sensor based tools and air quality monitoring systems are used widely in outdoor ambient claims.

**Benefits and Beneficiaries**

*Benefits*

1. Achievement of proper facility to ensure pollution free environment

2. Reduction of health risk in day-to-day life

*Beneficiaries*

1. Society People

2. Special Care Units in the hospitals

3. Urban and Rural planning sector and green building management system

# Literature Reviews

This section reviews some of the past works in processing and understanding IoT based air pollution detection monitoring system. Air pollution is not only natural medical matters impact on creating nations alike. The strong effect of air pollution on wellbeing are extremely mind blowing as there are a broad area of sources and their particular influence differ from one another. The synthetic substances reason an assortment of mankind and natural medical issues enlarge in air contamination impacts on condition also on human wellbeing. The proposed framework unit incorporates an Arduino, MQ135 Gas sensor, LCD and ESP8266 Wi-Fi Device. Almost all the past and recent works in IoT based on methods that implement these steps sequentially and independently.

**Opportunity of IoT**

The IoT create a huge network of billions or trillions of "Things" communicating each other. The IoT is not dissident revolution over the existing technologies, it is comprehensive uses of existing technologies, and it is the creation of the new communication modes. The IoT blends the virtual world and the physical world by transporting different concepts and technical components together: pervasive networks, reduction of devices, mobile communication, and new ecosystem. In IoT, applications, services, middleware components, networks, and end nodes to structurally planned and used in entire new ways. IoT proposals a means to look into complex procedures and dealings. The IoT implies a symbiotic communication between the physical and the digital worlds: physical entities have digital complements and virtual illustration; things become context aware and they sense, communicate, interact, and exchange data, information, and knowledge. New chances meet business requirements, and new servicesto be created based on real-time physical world data. All from the physical or virtual world possibly be connected by the IoT. Connectivity between the things to be available to all with low cost and cannot be owned by private objects. For IoT, intelligent learning, fast placement, best information understanding and interpreting, against fraud and malicious attack, and privacy protection are vital requirements.

**Status of IoT**

The IoT regarded as an extension of existing interaction between people and applications through a new dimension of "Things" for communication and integration. The IoT development process is a multifaceted large-scale technological novelty process. The IoT is developing from the vertical application to polymeric application. At the early stage of IoT placement, driving of domain specific requests is the main development approach. A domain specific application might be an industrial control system with its own industry features. The application can provide various enterprise management services being combined with the industry manufacture and business processes. Polymeric requests are cross-industry applications founded on public information service stages. These requests provision both home users and industry users. The application is provided and promoted by communication operators and solution providers with large scale. For example, a vehicle integrated with sensor networks, a global positioning system (GPS), and radio communication technology provide inclusive detection, navigation, entertainment, and other information services. By preserving such information through the public service platform, consumers, original equipment manufacturers (OEMs), maintenance providers, and vehicle organization agencies can share this information and segment services to improve the vehicle, the vehicle component design, and the fabrication process through the vehicle growth management.

**Capability of IoT**

In summary, the IoT applications have the following capabilities. Location Identifying and Sharing of Location Info: The IoT system can gather the location information of IoT stations and end nodes, and then offer services based on the collected location information. The location information includes geographical position information got from the GPS, Cell-ID, RFID, etc., and complete or relative position information between things. More representative IoT applications include at least the following.

*Mobile asset tracking:* This application track and display the status of product using the position sensing device and statement function installed on the commodity.

*Fleet management:* The manager of the fleet schedule the vehicles and drivers established on the business supplies and the real-time position information collected by the vehicles.

*Traffic information system:* This application gets traffic information such as road traffic conditions and congested locations by tracking the location information of a large number of vehicles. The system thus contributions the driver to select the most efficient route.

*Environment Sensing:* The IoT system collect and process all kinds of physical or chemical environmental parameters via the locally or widely organized terminals. Typical environmental information includes temperature, humidity, noise, visibility, light intensity, spectrum, radiation, pollution (CO, CO2, etc.), images, and body pointers. Representative applications include at least the following.

*Environment detection:* IoT systems offer environmental and ecological, such as forest and glacier, checking; disaster, such as volcanoes and seismic, monitoring; and factory monitoring. All are automatic alarm systems using environmental parameters collected by large number of sensors.

*Remote medical monitoring:* IoT analyze the recurring indicator data collected from the device placed on patients' body and provide the users with health trends and health advice.

*Remote Controlling:* IoT systems control IoT terminals and execute functions based on application commands combined with information collected from things and service requirements.

*Appliance control:* People remotely control operating status of appliances through IoT system.

*Disaster recovery:* Users remotely start disasters treatment facilities to minimize losses caused by disasters according to the monitoring mentioned before.

*Ad Hoc Networking:* IoT system have rapidly self-organized networking capability and can interoperate with the network/service layer to provide related services. In the vehicle network, in order to transfer the data, the network between vehicles and/or road infrastructures rapidly self-organized.

*Secure Communication:* IoT system further establish secure data transmission channel between the application or service platform and IoT terminals based on service requirements.

As seen in the previous overview to the current IoT, most IoT applications in China were domain-specific or application specific solutions. The architectures of these IoT systems are split and cannot correlate and integrate the data from different storage tower; these isolated IoT keys use private protocols and cause much difficulties in information sharing, technology multiplexing, network managements, and advancement. All these problems are delaying the development of IoT. In order to decrease the total IoT cost and share information, I need to 11 integrate multiple functions and capitals into a larger system. IoT thus needs to be intended with an open and generic IoT architecture with open borders and resources, considering different business scenarios, application-based requirements, and current technologies. I have thus seen the motivation to express a standard for IoT integration in order to reduce the total cost of money and time from devices, developments, and deployments. An open and basic IoT architecture is an integrated solution with interoperability. It has the following characteristics. Standard Interface and Protocol: By comparing various private IoT systems, a generic IoT structure has the same hardware and software interfaces, and protocols. Public and Operating: A general IoT architecture is organized to take over public IoT applications with open operating competence. A public IoT system integrate multiple IoT requests into one architecture. Open, Scalable, and Flexible: An open IoT architecture with open resources, open standards, and open interfaces easily extend its functionality and the scale of performance. It adapts to different requirements including technical growths flexibly.

The IoT incorporates several technologies such as information technology, cognitive sciences, communication technology, and low-power electronics. IoT creates a newer information society and information economy. But the trials from research, industries, and the government will keep pushing and investing. The expansion of IoT depend on technological advances in silicon scaling and energy-efficient devices, in getting the information from mixed sources, in reducing costs, and in refining efficiencies. The development of the IoT exposed many new challenges including the lack of essential theory supporting, unclear architecture, and undeveloped standards. To meet these challenges, we give a three-layer architecture including three platforms. The proposed acting standard can confidently balance desires from different parties, can open the door for future important theory development, and can eventually 17 stimulate/regulate IoT development. Recent years, Chinese government is pushing the expansion of the IoT. Following the Chinese 12th Five-Year Plan for IoT Development, China has skillful a number of demonstration application projects such as the smart city and the intelligent transportation system in public IoT applications, intelligent coal mine, and the IOFs in industry claims. The future of IoT will be predictable to be unified, seamless, and pervasive. Large-scale service deployment needs to be enclosed within a set of standards. Thus, the developments of IoT as a brainy system can be proceeding with interoperability, energy sustainability, privacy, and security. IoT have become a predictable trend of development of information industry, which certain to bring new changes to our lives.

# Analysis of Air Pollution during lockdown and before lockdown

jupyter air_pollution Last Checkpoint: 12 hours ago (unsaved changes)

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## Realtime pollution analysis

api : http://api.waqi.info/

Get your api key from here : https://aqicn.org/data-platform/token/#/

Getting data

In [0]:
```python
import requests
```

In [80]:
```python
city = 'kanpur'
url = 'http://api.waqi.info/feed/' + city + '/?token='
api_key = '37f96394ffe8b6cca1110af3d8270604c711c688'

main_url = url + api_key
r = requests.get(main_url)
data = r.json()['data']
data
```

Out[80]:

```
{'aqi': 151,
 'attributions': [{'logo': 'India-CPCB.png',
   'name': 'CPCB - India Central Pollution Control Board',
   'url': 'http://cpcb.nic.in/'},
  {'name': 'World Air Quality Index Project', 'url': 'https://waqi.info/'}],
 'city': {'geo': [26.4703088, 80.3251749],
  'name': 'Nehru Nagar, Kanpur, India',
  'url': 'https://aqicn.org/city/india/kanpur/nehru-nagar'},
 'debug': {'sync': '2020-04-16T17:36:29+09:00'},
 'dominentpol': 'pm25',
 'iaqi': {'dew': {'v': 18},
```


jupyter air_pollution Last Checkpoint: 12 hours ago (autosaved)

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```
  'url': 'https://aqicn.org/city/india/kanpur/nehru-nagar'},
 'debug': {'sync': '2020-04-16T17:36:29+09:00'},
 'dominentpol': 'pm25',
 'iaqi': {'dew': {'v': 18},
  'h': {'v': 43},
  'no2': {'v': 5.7},
  'o3': {'v': 31.4},
  'p': {'v': 742},
  'pm25': {'v': 151},
  'so2': {'v': 8.6},
  't': {'v': 36.125},
  'w': {'v': 2.275}},
 'idx': 8187,
 'time': {'s': '2020-04-16 13:00:00', 'tz': '+05:30', 'v': 1587042000}}
```


Extracting air quality information

In [0]:
```python
aqi = data['aqi']
iaqi = data['iaqi']

del iaqi['p']

for i in iaqi.items():
    print(i[0],':',i[1]['v'])
```

```
dew : 19
h : 47.666666666666664
no2 : 10.2
o3 : 35.5
pm25 : 168
so2 : 10.6
t : 33.699999999999996
w : 2
```

In [0]:
```python
dew = iaqi.get('dew','Nil')
```

```
In [0]: dew = iaqi.get('dew','Nil')
        no2 = iaqi.get('no2','Nil')
        o3 = iaqi.get('o3','Nil')
        so2 = iaqi.get('so2','Nil')
        pm10 = iaqi.get('pm10','Nil')
        pm25 = iaqi.get('pm25','Nil')

        print(f'{city} AQI :',aqi,'\n')
        print('Individual Air quality')
        print('Dew :',dew)
        print('no2 :',no2)
        print('Ozone :',o3)
        print('sulphur :',so2)
        print('pm10 :',so2)
        print('pm25 :',pm25)
```

```
kanpur AQI : 168

Individual Air quality
Dew : {'v': 19}
no2 : {'v': 10.2}
Ozone : {'v': 35.5}
sulphur : {'v': 10.6}
pm10 : {'v': 10.6}
pm25 : {'v': 168}
```

Plotting pollutants graph

```
In [0]: import matplotlib.pyplot as plt

        pollutants = [i for i in iaqi]
        values = [i['v'] for i in iaqi.values()]
```

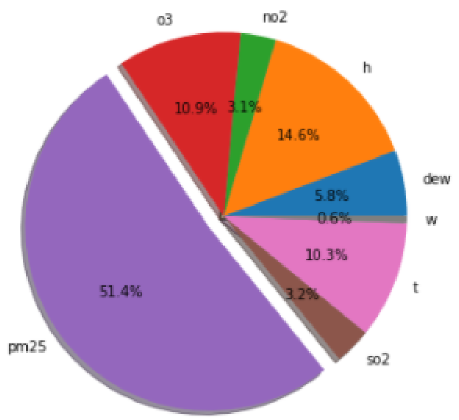
```
# Exploding the first slice
explode = [0 for i in pollutants]
mx = values.index(max(values))  # explode 1st slice
explode[mx] = 0.1

# Plot a pie chart
plt.figure(figsize=(8,6))
plt.pie(values, labels=pollutants,explode=explode,autopct='%1.1f%%', shadow=True)

plt.title('Air pollutants and their probable amount in atmosphere [kanpur]')

plt.axis('equal')
plt.show()
```

```
['dew', 'h', 'no2', 'o3', 'pm25', 'so2', 't', 'w']
[19, 47.666666666666664, 10.2, 35.5, 168, 10.6, 33.699999999999996, 2]
```



In [0]:
```
!apt-get install libproj-dev proj-data proj-bin
!apt-get install libgeos-dev
!pip install cython
!pip install cartopy
```

In [0]:
```
!pip uninstall shapely
!pip install shapely --no-binary shapely
```

Installing cartopy in normal python / anaconda

watch installation tutorial : [Installing Cartopy]()

In [0]:
```
# conda install -c conda-forge cartopy
```

Plotting a map of the city

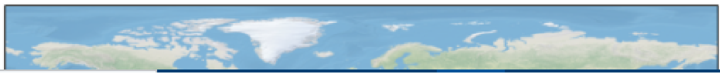
In [0]:
```
import cartopy.crs as ccrs

geo = data['city']['geo']

fig = plt.figure(figsize=(10,8))
ax = plt.axes(projection=ccrs.PlateCarree())
ax.stock_img()

plt.scatter(geo[1],geo[0],color='blue')
plt.text(geo[1] + 3,geo[0]-2,f'{city} AQI \n    {aqi}',color='red')

plt.show()
```



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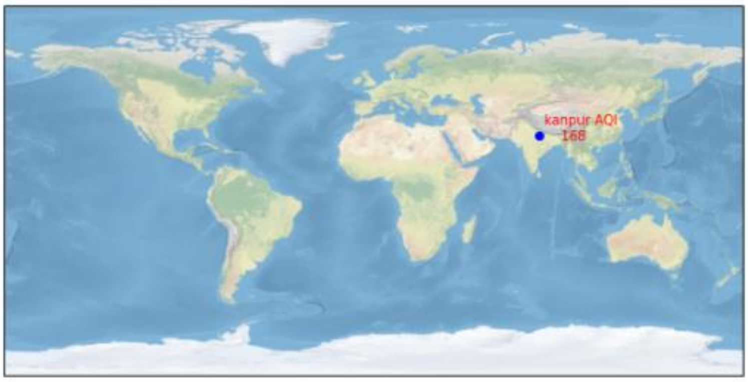
```


# Historical data analysis

## Historical data analysis

dataset : http://aqicn.org/data-platform/register/

Read csv files into a dataframe

In [0]:
```
import pandas as pd

csv_path = '/content/drive/My Drive/Colab Notebooks/Data and Visulization/Air pollution/nehru-nagar, kanpur-ai

df = pd.read_csv(csv_path)
df = df.head(50)
print(df)
```

Out[55]:

| | date | pm25 | pm10 | o3 | no2 | so2 | co |
|---|---|---|---|---|---|---|---|
| 0 | 2020/4/1 | 122 | | 23 | 4 | 6 | |
| 1 | 2020/4/2 | 97 | | 27 | 3 | 7 | |
| 2 | 2020/4/3 | 67 | | 28 | 3 | 7 | |
| 3 | 2020/4/4 | 91 | | | | | |
| 4 | 2020/4/6 | 99 | | 24 | 3 | 8 | |
| 5 | 2020/4/7 | 107 | | 25 | 4 | 4 | |
| 6 | 2020/4/8 | 93 | | 29 | 3 | 4 | |
| 7 | 2020/4/9 | 86 | | 31 | 8 | 11 | |
| 8 | 2020/4/10 | 111 | | 31 | 16 | 10 | |
| 9 | 2020/4/11 | 145 | | 26 | 8 | 8 | |
| 10 | 2020/4/12 | 116 | | 28 | 12 | 16 | |
| 11 | 2020/4/13 | 121 | | 31 | 11 | 9 | |

Renaming column names

In [0]:
```
df.columns

df= df.rename(columns = {" pm25": "pm25",
                         " pm10":"pm10",
                         " o3": "o3",
                         ' no2' : 'no2',
                         ' so2' : 'so2',
                         ' co' : 'co'})

df.columns
```

Out[57]: `Index(['date', 'pm25', 'pm10', 'o3', 'no2', 'so2', 'co'], dtype='object')`

Extract dates of lockdown

In [0]:
```
df['date'] = pd.to_datetime(df.date)

df21 = df.loc[df['date'] > '2020-03-24']
df21 = df21.sort_values(by = 'date')
df21
```

Out[60]:

| | date | pm25 | pm10 | o3 | no2 | so2 | co |
|---|---|---|---|---|---|---|---|
| 38 | 2020-03-25 | 124 | | 19 | 4 | 6 | |
| 39 | 2020-03-26 | 100 | | 12 | 4 | 8 | |
| 40 | 2020-03-27 | 115 | | 22 | 3 | 6 | |
| 41 | 2020-03-28 | 91 | | 21 | 2 | 6 | |
| 42 | 2020-03-29 | 78 | | 24 | 3 | 7 | |
| 43 | 2020-03-30 | 87 | | 26 | 5 | 7 | |
| 44 | 2020-03-31 | 109 | | 27 | 5 | 7 | |

In [0]:
```python
df21.drop(13, inplace=True)
df21
```

Out[61]:

| | date | pm25 | pm10 | o3 | no2 | so2 | co |
|---|---|---|---|---|---|---|---|
| 38 | 2020-03-25 | 124 | | 19 | 4 | 6 | |
| 39 | 2020-03-26 | 100 | | 12 | 4 | 8 | |
| 40 | 2020-03-27 | 115 | | 22 | 3 | 6 | |
| 41 | 2020-03-28 | 91 | | 21 | 2 | 6 | |
| 42 | 2020-03-29 | 78 | | 24 | 3 | 7 | |
| 43 | 2020-03-30 | 87 | | 26 | 5 | 7 | |
| 44 | 2020-03-31 | 109 | | 27 | 5 | 7 | |
| 0 | 2020-04-01 | 122 | | 23 | 4 | 6 | |
| 1 | 2020-04-02 | 97 | | 27 | 3 | 7 | |
| 2 | 2020-04-03 | 67 | | 28 | 3 | 7 | |
| 3 | 2020-04-04 | 91 | | | | | |
| 4 | 2020-04-06 | 99 | | 24 | 3 | 8 | |
| 5 | 2020-04-07 | 107 | | 25 | 4 | 4 | |
| 6 | 2020-04-08 | 93 | | 29 | 3 | 4 | |
| 7 | 2020-04-09 | 86 | | 31 | 8 | 11 | |
| 8 | 2020-04-10 | 111 | | 31 | 16 | 10 | |
| 9 | 2020-04-11 | 145 | | 26 | 8 | 8 | |
| 10 | 2020-04-12 | 116 | | 28 | 12 | 16 | |
| 11 | 2020-04-13 | 121 | | 31 | 11 | 9 | |
| 12 | 2020-04-14 | 136 | | 12 | 12 | 10 | |

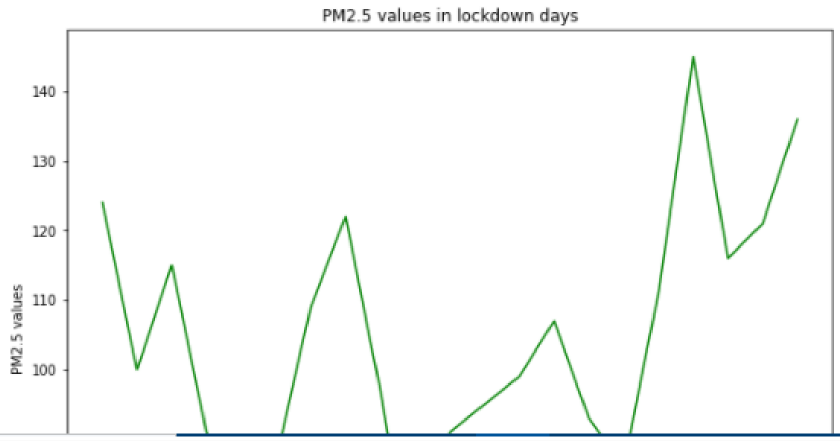
In [0]:
```python
df21.replace(' ', '0', inplace=True)
df21
```

Out[62]:

| | date | pm25 | pm10 | o3 | no2 | so2 | co |
|---|---|---|---|---|---|---|---|
| 38 | 2020-03-25 | 124 | 0 | 19 | 4 | 6 | 0 |
| 39 | 2020-03-26 | 100 | 0 | 12 | 4 | 8 | 0 |
| 40 | 2020-03-27 | 115 | 0 | 22 | 3 | 6 | 0 |
| 41 | 2020-03-28 | 91 | 0 | 21 | 2 | 6 | 0 |
| 42 | 2020-03-29 | 78 | 0 | 24 | 3 | 7 | 0 |
| 43 | 2020-03-30 | 87 | 0 | 26 | 5 | 7 | 0 |
| 44 | 2020-03-31 | 109 | 0 | 27 | 5 | 7 | 0 |
| 0 | 2020-04-01 | 122 | 0 | 23 | 4 | 6 | 0 |
| 1 | 2020-04-02 | 97 | 0 | 27 | 3 | 7 | 0 |
| 2 | 2020-04-03 | 67 | 0 | 28 | 3 | 7 | 0 |
| 3 | 2020-04-04 | 91 | 0 | 0 | 0 | 0 | 0 |
| 4 | 2020-04-06 | 99 | 0 | 24 | 3 | 8 | 0 |
| 5 | 2020-04-07 | 107 | 0 | 25 | 4 | 4 | 0 |
| 6 | 2020-04-08 | 93 | 0 | 29 | 3 | 4 | 0 |
| 7 | 2020-04-09 | 86 | 0 | 31 | 8 | 11 | 0 |
| 8 | 2020-04-10 | 111 | 0 | 31 | 16 | 10 | 0 |
| 9 | 2020-04-11 | 145 | 0 | 26 | 8 | 8 | 0 |
| 10 | 2020-04-12 | 116 | 0 | 28 | 12 | 16 | 0 |
| 11 | 2020-04-13 | 121 | 0 | 31 | 11 | 9 | 0 |
| 12 | 2020-04-14 | 136 | 0 | 12 | 12 | 10 | 0 |

Plotting the data

In [0]:
```python
import matplotlib.pyplot as plt

dates = df21['date']
pm25 = df21['pm25']
pm25 = [int(i) for i in pm25]

plt.figure(figsize=(10,8))

length = len(dates)

plt.plot(dates,pm25)
plt.title('PM2.5 values in lockdown days')
plt.xlabel('Dates of lockdown')
plt.ylabel('PM2.5 values')
plt.show()
```



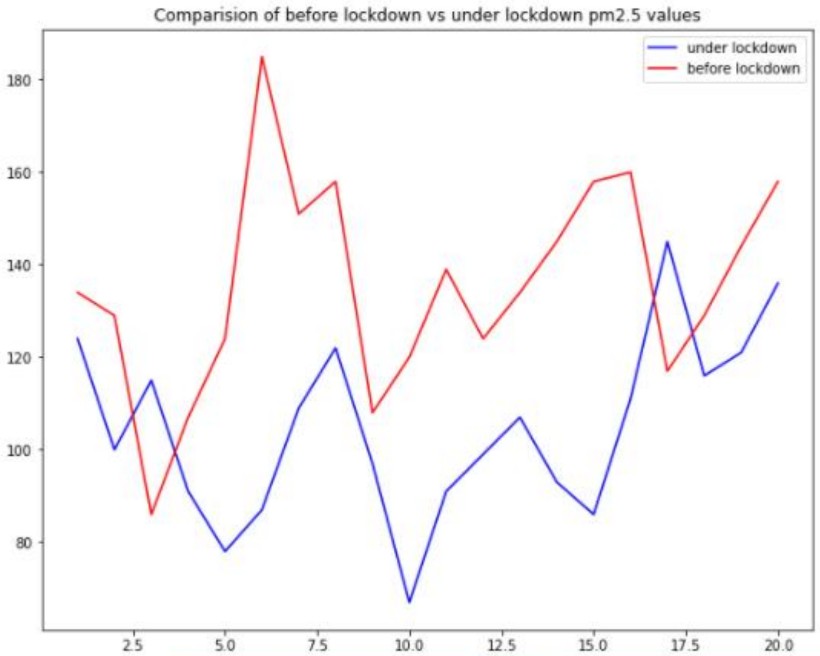

In [0]:
```python
mask = (df['date'] >= '2020-03-05') & (df['date']  < '2020-03-25')

past21 = df.loc[mask]
past21
```

Out[68]:

| | date | pm25 | pm10 | o3 | no2 | so2 | co |
|---|---|---|---|---|---|---|---|
| **18** | 2020-03-05 | 134 | | 20 | 13 | 4 | |
| **19** | 2020-03-06 | 129 | | 20 | 13 | 3 | |
| **20** | 2020-03-07 | 86 | | 22 | 15 | 3 | |
| **21** | 2020-03-08 | 107 | | 24 | 20 | 4 | |
| **22** | 2020-03-09 | 124 | | 20 | 19 | 5 | |
| **23** | 2020-03-10 | 185 | | 23 | 14 | 7 | |
| **24** | 2020-03-11 | 151 | | 26 | 20 | 10 | |
| **25** | 2020-03-12 | 158 | | 16 | 13 | 5 | |
| **26** | 2020-03-13 | 108 | | 18 | 20 | 5 | |
| **27** | 2020-03-14 | 120 | | 20 | 14 | 5 | |
| **28** | 2020-03-15 | 139 | | 24 | 27 | 5 | |
| **29** | 2020-03-16 | 124 | | 30 | 23 | 12 | |
| **30** | 2020-03-17 | 134 | | 27 | 25 | 11 | |
| **31** | 2020-03-18 | 145 | | 29 | 27 | 18 | |
| **32** | 2020-03-19 | 158 | | 30 | 28 | 12 | |
| **33** | 2020-03-20 | 160 | | 21 | 14 | 10 | |
| **34** | 2020-03-21 | 117 | | 25 | 11 | 8 | |
| **35** | 2020-03-22 | 129 | | 27 | 10 | 8 | |
| **36** | 2020-03-23 | 144 | | 28 | 11 | 8 | |

```
plt.plot(length,pm25_l,color='blue',label='under lockdown')
plt.plot(length,pm25_n,color='red',label='before lockdown')
plt.legend()
plt.title('Comparision of before lockdown vs under lockdown pm2.5 values')
plt.show()
```

Out[76]: []




1> On which date pm2.5 value was minimum in kanpur under lockdown

In [0]:
```
df21['pm25'] = [int(i) for i in df21['pm25']]
print(df21[df21.pm25 == df21.pm25.min()])
```

```
         date  pm25  pm10  o3  no2  so2  co
2  2020-04-03    67     0  28    3    7   0
```

2> On which date o3 value was maximum in kanpur under lockdown

In [0]:
```
df21['o3'] = [int(i) for i in df21['o3']]
print(df21[df21.o3 == df21.o3.max()])
```

```
          date  pm25  pm10  o3  no2  so2  co
7   2020-04-09    86     0  31    8   11   0
8   2020-04-10   111     0  31   16   10   0
11  2020-04-13   121     0  31   11    9   0
```

3> What is the average value of so2 in the lockdown

In [0]:
```
df21['so2'] = [int(i) for i in df21['so2']]
avgSo2 = df21['so2'].mean()
print('The average value of so2 :',avgSo2)
```

```
The average value of so2 : 7.35
```

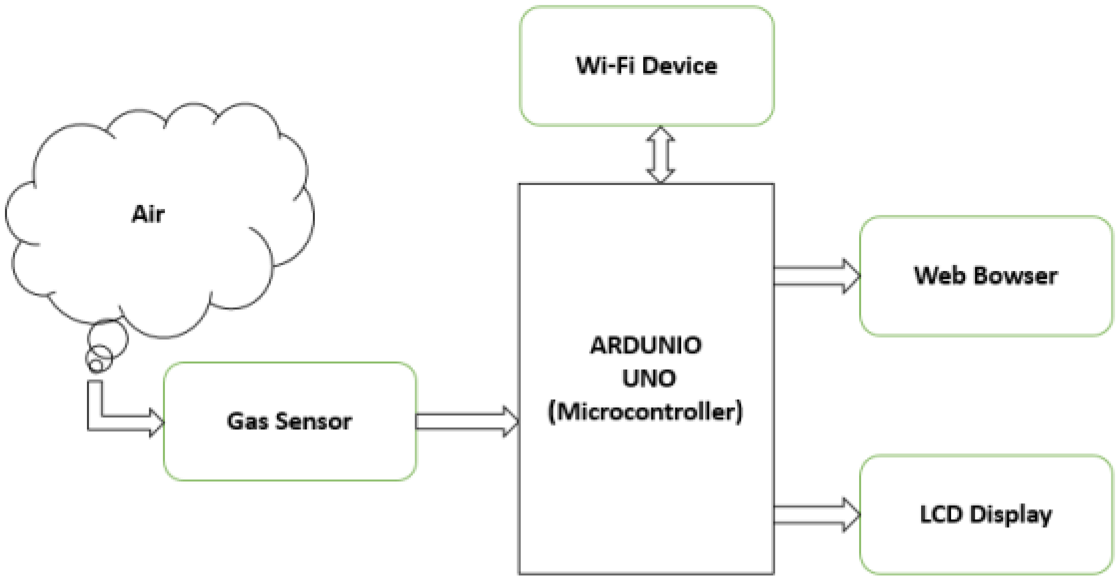
# Methodology

The project aims at designing an air pollution monitoring system which can be installed in a specific locality and to enhance the system from the previously developed systems beating the earlier disadvantages by developing an android app available for the public. This app can be used by anyone to get in live updates about the pollution in their region. It uses Arduino integrated with individual gas sensors like carbon monoxide, ammonia along with particulate matter, humidity, and smoke which measures the concentration of each gas separately. The collected data is uploaded to the cloud using thing speak platform at regular time intervals. Ethernet shield is used for connecting Arduino and cloud. Pictorial or graphical representation of values can be shown in Thing speak. The users can install an android application through which they get the recent updates and graphical content up to date. The average concentration of each gas is analyzed using matlab. Then certain time control is assigned based on the standard level of each gas measured and the result can be viewed in android application. The architecture of air pollution monitoring and awareness creation system. The concentration level of each gas can be viewed both as a graph and in numerical format. Based on these values the air quality index value is calculated and the nature of the air quality in that area is determined which is also displayed through the app. Along with this, the health effects for the corresponding air quality is displayed to create awareness among the public. Additionally, they could also get to know the temperature and weather in that region. The users will not get disturbed with irrelevant data as the values displayed are location specific and help them stay tuned to the current status of air pollution.

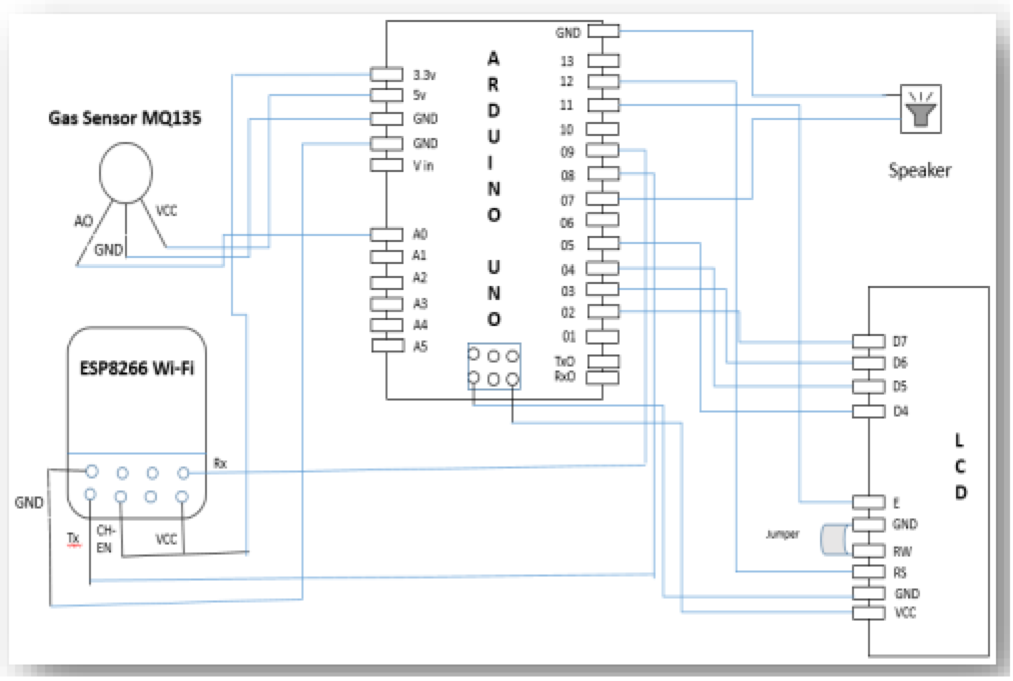
**Proposed System Architecture**

Internet of Things (IoT) mainly deals with connecting smart devices to internet by joining the advantage of OSI layered Architecture. In the context of this work we propose a cluster of Air Quality Monitoring Gas Sensor MQ135 motes, which are used to measure the concentration of Air pollutants in the air. The Gas Sensors MQ135 is interface with a tiny entrenched platform equipped with other. We have mainly used the Arduino UNO which is an open source development boards with ESP8266-12E chips. MQ135 Gas Sensor is used to collect gas concentration measurements. This sensor data would be captured and sent to the Arduino UNO for IoT (Internet of Things) based data acquirement.

The major components of this project have been mentioned in the above section. Here I explain the architecture. Gas sensor & Wi-Fi Device are connected to the Arduino board. Also LCD connected to the Arduino board for displaying information. We can monitor the Air Quality over a serial monitor & LCD using Gas sensor and trigger an alarm when the air quality goes down beyond a certain level, means when there is sufficient amount of harmful gases are present in the air like CO2, smoke, alcohol, benzene and NH3. It is shown the air quality in PPM on the LCD as well as serial monitor so that we can monitor it very easily. We have used MQ135 sensor which is the best choice for monitoring Air Quality as it can detect most harmful gases and can measure their amount accurately. In this Internet of Things (IoT) project, We can monitor the pollution level from anywhere using computer.




**CIRCUIT DIAGRAM**




We connect the ESP8266 with the Arduino. ESP8266 runs on 3.3V and connect the VCC and the CH_EN to the 3.3V pin of Arduino. The RX pin of ESP8266 works on 3.3V and it communicate with the Arduino when I connect it directly to the Arduino. So, we have to make a voltage divider for it which convert the 5V into 3.3V. This can be done by connecting three resistors in series like we did in the circuit. Connect the TX pin of the ESP8266 to the pin 8 of the Arduino and the RX pin of the esp8266 to the pin 9 of Arduino. ESP8266 Wi-Fi module gives my projects access to Wi-Fi or internet. Then we connect the MQ135 sensor with the Arduino. Connect the VCC and the ground pin of the sensor to the 5V and ground of the Arduino and the Analog pin of sensor to the A0 of the Arduino. Connect a buzzer to the pin 7 of the Arduino which start to beep when the condition becomes true. In last, we connect LCD with the Arduino.

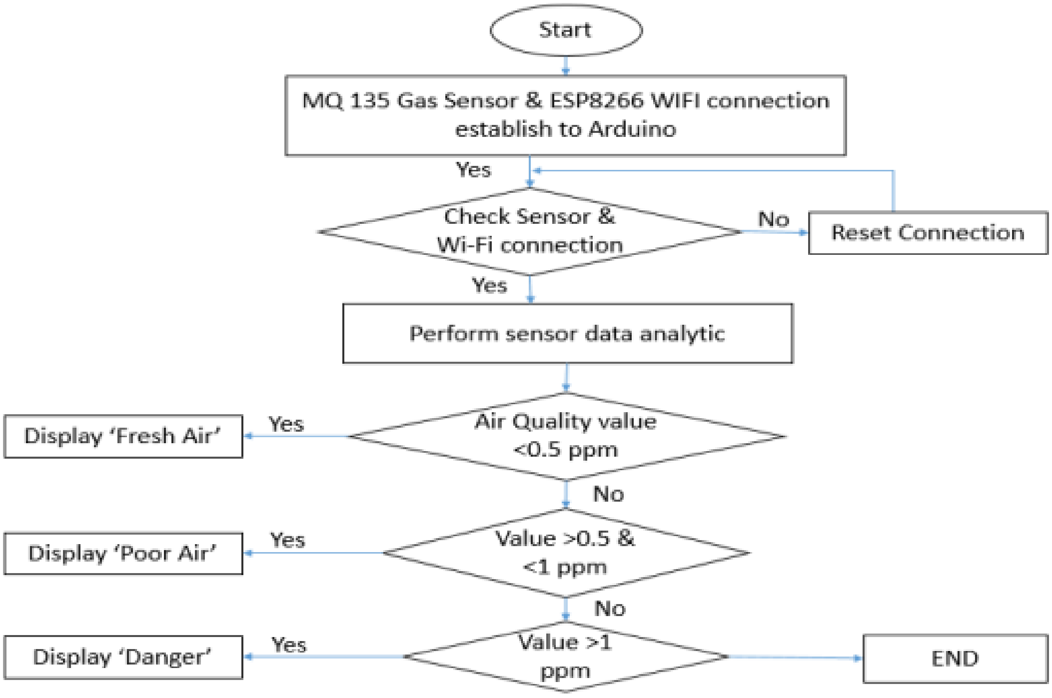
# Implementation

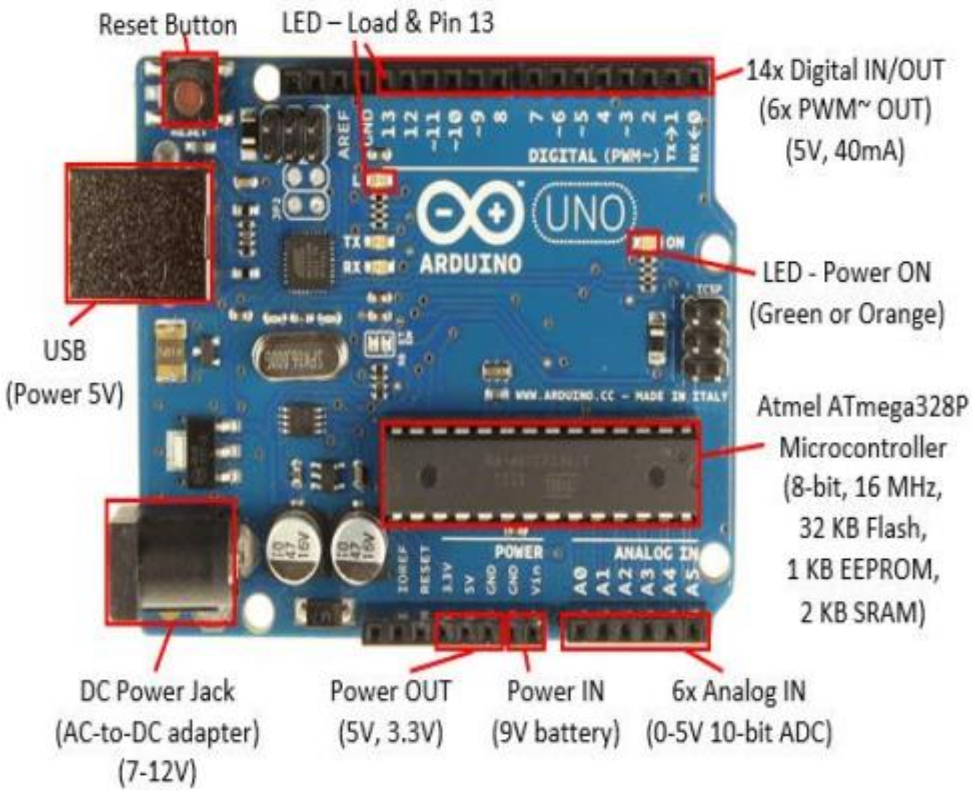
We have connected the MQ135 gas sensor and ESP8266 Wi-Fi device with the Arduino. Connected the VCC and the ground pin of the sensor to the 5V and ground of the Arduino and the Analog pin of sensor to the A0 of the Arduino. Connected a buzzer to the pin 7 of the Arduino which is start to beep when the condition becomes true. The MQ135 sensor can sense NH3, NOx, alcohol, Benzene, smoke, CO2 and some other gases, so it is faultless gas sensor for our Air Quality Observing Detection Project. When we connect it to Arduino then it senses the gases, and I get the Pollution level in PPM (parts per million). MQ135 gas sensor gives the output in form of voltage levels and I need to convert it into PPM. Sensor is giving us value of 0.1 when there is no gas near it and the safe level of air quality is 0.5 PPM and it is not exceeding 0.5 PPM. When it exceeds the limit of 0.5 PPM, then it starts cause Headaches, sleepiness and stagnant, stale, stuffy air and if exceeds beyond 1 PPM then it can cause increased heart rate and many other diseases. When the value is being less than 0.5 PPM, then the LCD and serial monitor is displayed “Fresh Air”. Whenever the value is increased 0.5 23 PPM, then serial monitor is displayed “Poor Air, Open Windows”. If it is increased 1 PPM, then the buzzer is kept beeping and the LCD is displayed “Danger! Move to fresh Air”. After uploading the code, we are connected to the Wi-Fi of my ESP8266 device, the serial monitor has opened and it is showing the IP address like shown below (192.168.43.57). If we have typed mentioned IP address in my browser, it is shown the output as below. we have to refresh the page again if I want to see the current Air Quality Value in PPM. After uploading code, the value is being less than 0.5 PPM, then the LCD and Web Browser is displayed “Fresh Air”. After uploading code, the value is increased 0.5 PPM, then the LCD and web browser are displayed “Poor Air, Open Windows”. After uploading code, When the value is increased 1.00 PPM then the buzzer is kept beeping and the LCD and Web Browser are displayed “Danger! Move to fresh Air”.

**Implementation Technologies** - It’s 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 analog data from the environment which later is converted into digital with the help of Arduino and then sent to the server where all the data are stored. This device is consisting of the following components:

i. Arduino Uno
ii. Gas sensor MQ135
iii. ESP8266 Wi-Fi Device
iv. 16x2 LCD
v. Buzzer
vi. 0.5m Arduino A-B Cable
vii. Jumper wire

**Flowchart**




**Arduino Uno Microcontroller**

# Result Analysis

### Codding Explanation

At first, we need to connect my Wi-Fi module to Wi-Fi router for network connectivity. Then we configure the local server, send the data to web and finally close the connection. This process and commands have been explained in below steps:

1. First we need to test the Wi-Fi module by sending AT command, it revert back a response containing OK.

2. After this, we need to select mode using command AT+CWMODE=mode_id , we have used Mode id =3. Mode ids:

1 = Station mode (client)

2 = AP mode (host)

3 = AP + Station mode (Yes, ESP8266 has a dual mode!)

3. Now we need to disconnect my Wi-Fi module from the previously connected Wi-Fi network, by using the command AT+CWQAP, as ESP8266 is default auto connected with any previously available Wi-Fi network

4. After that, user can reset the module with AT+RST command. This step is optional.

5. Now we need to connect ESP8266 to Wi-Fi router using given command AT+CWJAP=" wifi_username","wifi_password"

6. Now get IP Address by using given command: AT+CIFSR It returns an IP Address.

7. Now enable the multiplex mode by using AT+CIPMUX=1 (1 for multiple connection and 0 for single connection)

8. Now configure ESP8266 as server by using AT+CIPSERVER=1, port_no (port may be 80). Now your Wi-Fi is ready. Here '1' is used to create the server and '0' to delete the server.

9. Now by using given command user can send data to local created server: AT+CIPSEND =id, length of data Id = ID no. of transmit connection Length = Max length of data is 2 kb

10. After sending ID and Length to the server, we need to send data like: Serial.println

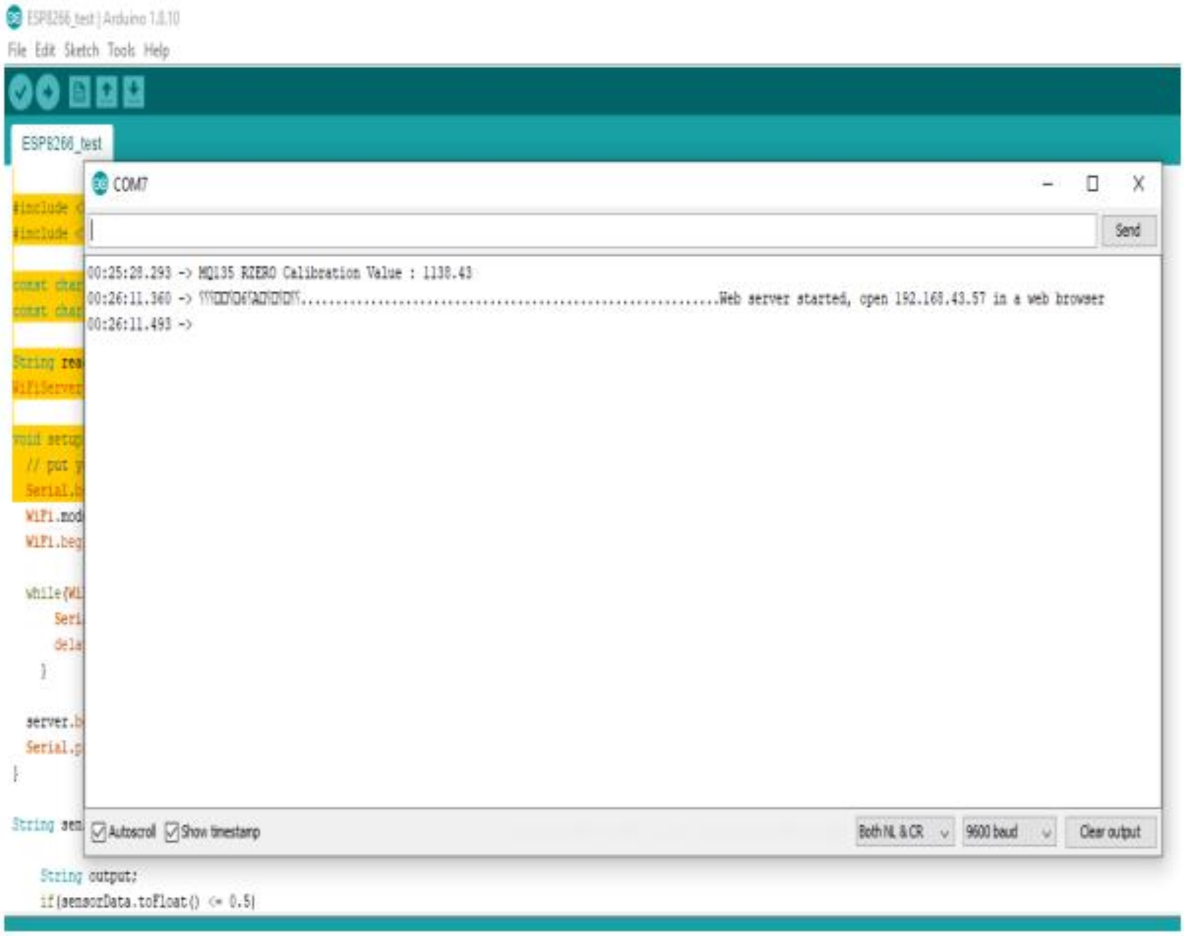
11. After sending data I need close the connection by given command: AT+CIPCLOSE=0 Now data has been transmitted to local server.

12. Now type IP Address in Address Bar in web browser and hit enter. Now user can see transmitted data on webpage.

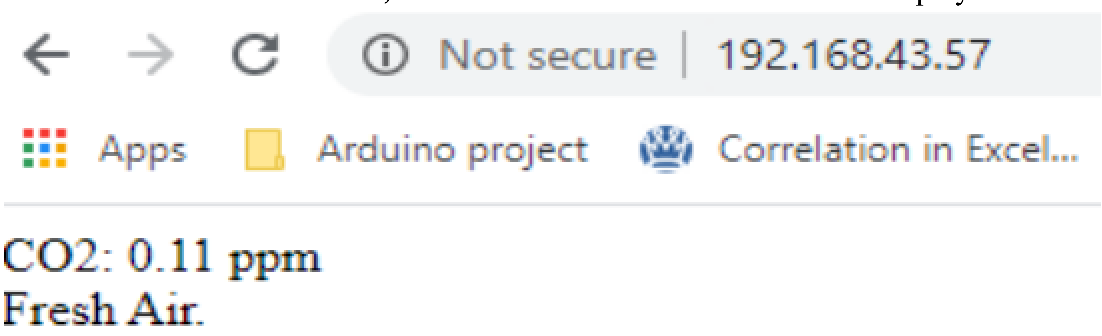
### Result

The MQ135 sensor can sense CO2 and some other gases, so it is perfect gas sensor for my Air Quality Monitoring Detection System Project. When we connect it to Arduino then it senses the gases, and I get the Pollution level in PPM (parts per million). MQ135 gas sensor gives the output in form of voltage levels and I need to convert it into PPM. So for converting the output in PPM. Sensor is giving me value of 0.1 when there was no gas near it and the safe level of air quality is 0.5 PPM and it is not exceeding 0.5 PPM. When it exceeds the limit of 0.5 PPM, then it starts cause Headaches, sleepiness and stagnant, stale, stuffy air and if exceeds beyond PPM then it can cause increased heart rate and many other diseases. When the value less than 0.5 PPM, then the LCD and webpage will display “Fresh Air”. Whenever the value increase 0.5 PPM, then the LCD and webpage will display “Poor Air, Open Windows”. If it increases 1 PPM, then the buzzer keeps beeping and the LCD and webpage will display “Danger! Move to fresh Air”.

After uploading the code, we are connected to the Wi-Fi of my ESP8266 device, the serial monitor has opened and it is showing the IP address like shown below (192.168.43.57).

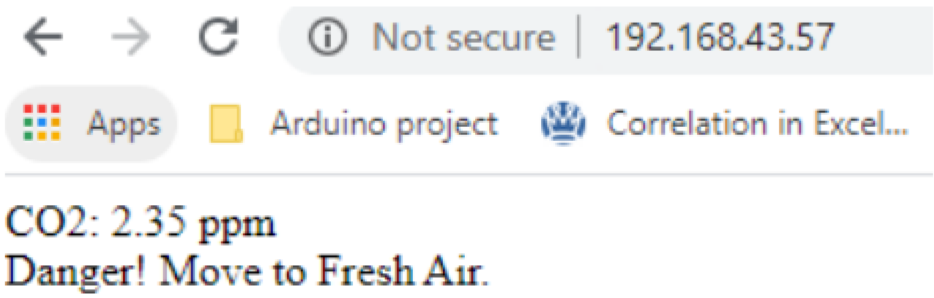



Type this IP address in your browser, it shows the output as shown below. we have to refresh the page again if we want to see the current Air Quality Value in PPM. After uploading code, When the value less than 0.5 PPM, then the LCD and Web Browser will display “Fresh Air”.



when the value increase 0.5 PPM, then the LCD and web browser display “Poor Air, Open Windows”.


when the value increase 1 PPM then the buzzer keeps beeping and the LCD and Web Browser display “Danger! Move to fresh Air”




| **MQ135 Sensor Detect** | **Air Quality Value (AQV)** | **Display Result** |
|---|---|---|
| $CO_2$ | AQV<0.5 PPM | Fresh Air |
| $CO_2$ | AQV>0.5 & AQV<1 PPM | Poor Air |
| $CO_2$ | AQV>1 PPM | Danger |

**Air Quality Range wise Result**

**Analysis**

The following table shows that the air quality health and its risk through a 0.1-1.0 base scale. It is divided into three parts like as Fresh Air, Poor Air & Danger Air. It detects the air pollution level and indicates the risk through this scale. When the updated data compared to the base data then it shows the result accordingly to this scale. The compared data is between 0.1-0.5 it shows that health risk is low and indicate open window, when it rises up to 0.6-1.0 it shows that the pollution in the air is considered dangerous for human being and I take some steps quickly.

| Air Quality Indicator Range (PPM) | Result | Health Impacts |
|---|---|---|
| 0-0.5 | Fresh Air | Minimal impact |
| 0.6-0.9 | Poor Air | May cause minor breathing discomfort to sensitive people. |
| 1 to above | Danger Air | May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults. |

**AQI levels and Connected Health Impacts**

# Conclusion

The system to monitor the air of environment using Arduino microcontroller, IoT Technology is proposed to improve quality of air. With the use of IoT technology enhances the process of monitoring various aspects of environment such as air quality monitoring issue proposed in this project. Here, using the MQ135 gives the sense of different type of dangerous gas and Arduino is the heart of this project. Which control the entire process, Arduino module connects the whole process to LCD and serial monitor is used for the visual Output.

### Future Scope

The future scope is that device which we are having can be done in a compact way by reducing the size of the device for further implementation or the modifications which can be is that detecting the vehicles amount of pollution which can be determined. In future the range can be made increased according to the bandwidth for the high range frequencies. Further research can be made by making the people in the right direction for their welfare. Therefore, there is another beneficiary by using this device in an app so all can be used in an GSM mobile phones for their daily updates by increasing their range

#### References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