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Detecting Impact of COVID -19 on Air Quality Index Using Air Pollution Monitoring System

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Abstract: *The fatal novel coronavirus (COVID-19) pandemic disease disturbs the normal rhythm of the global economy. To arrest the rapid transmission of this virus into the human body many countries imposed a lockdown system. People, on the other hand, have been facing a critical issue i.e. air pollution, which has become one of the major causes of concern around the world. With taking necessary actions against Covid-19 it is also necessary to constantly monitor the air quality index of a city to make it smart and livable The pollution data of different cities of like PM2.5, PM10, NO, NO_2, NOx, NH_3, CO, SO_2, O_3, Benzene, Toluene, Xylene have been collected from open source Kaggle dataset. But surprisingly it can be seen that due to lockdown AQI has been improved due to less number of vehicles and industrial emissions. To monitor the Air Quality an IoT Based Pollution Monitoring System [3] will be beneficial as existing monitoring systems require laboratory analysis. Therefore, requirements for improved monitoring systems have come into place. We propose a pollution monitoring system that will show the air quality in PPM on a webpage so that monitoring will be easy. In this paper, we have shown pollution levels can be monitored anywhere using devices like mobile or computer. The system uses MQ2, MQ7, and MQ135 sensors which measure the amount and type of harmful gases.*

***Key Words*: COVID-19, Air Quality Index, Air monitoring systems, Air pollution, Particulate matter, IoT.**

1. INTRODUCTION

According to WHO, approximately 91% of the world's population resides in places where pollutant levels exceed thresholds of the WHO air quality guidelines; ambient air pollution is estimated to cause 4.2 million premature deaths globally. The highest levels of air pollution, especially in Asian mega-cities, were found linked to population growth and industrialization. Though restriction during lockdown and reduction in human activities after the COVID-19 outbreak may decline the economy, also has a positive effect on air pollution levels. From 23rd March nationwide lockdown was imposed. Restrictions during lockdown almost stop people's movement as they can leave home only to purchase essential items, which meant almost fewer movements of essential vehicle services, restricted movements of trucks, no construction, no industries running, or no construction. As a result, the environment starts to heal. This study aimed to investigate changes in air pollution of particulate matter with an aerodynamic diameter less than 2.5 or 10 μm (PM2.5, PM10), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), and ozone (O_3) during the "lockdown" period after the COVID-19 outbreak in India, using air pollution data hourly-detected from nationwide monitoring stations.

Let's first try and understand the various types of air pollutants in the datasets. On a broader level, these pollutants can be classified as:

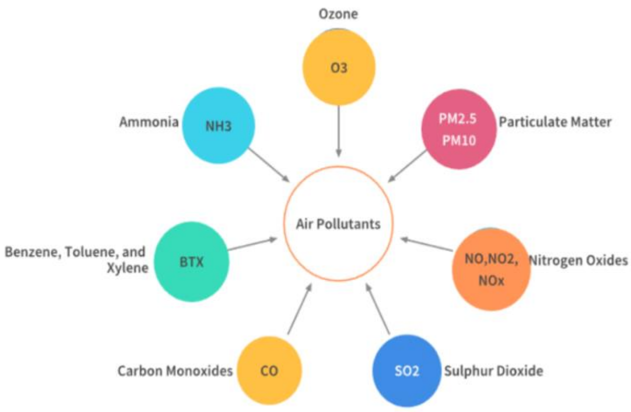


Fig -1: Types of Pollutants

Types of Pollutants

- **Particulate matter (PM2.5 and PM10)**: - Particulate matter is a mix of solids and liquids, including carbon, complex organic chemicals, sulfates, nitrates, mineral dust, and water suspended in the air. PM varies [11] in size. Some particles can be seen in naked eyes such as dust, soot, dirt, or smoke. But being smaller particles, there are two more pollutants known as PM10 and PM2.5 that are most damaging.
- **Nitrogen Oxides (NO, NO_2, NOx): -**Nitrogen oxides are a group of seven gases and compounds composed of nitrogen and oxygen, sometimes collectively known as NOx gases. Among them, nitric oxide (NO) and nitrogen dioxide(NO_2) is the

most common and hazardous oxides forms of nitrogen.

- **Sulphur Dioxide (SO_2)**: - Sulfur dioxide or SO_2 is a colorless gas with a strong odor, similar to a just-struck match. While burning when fuel containing sulfur, such as coal and oil, is burned, creates air pollution.
- **Carbon Monoxide (CO)**: -Carbon monoxide is a colorless, highly poisonous gas. Under pressure, it becomes a liquid. While burning gasoline, natural gas, charcoal, wood, and other fuels produce CO.
- **Benzene, Toluene, and Xylene (BTX)**: - Benzene, toluene, xylene, and formaldehyde are well-known indoor air pollutants, especially after house decoration. The plastic industry, chemical industry, and leather industry produce common pollutants.
- **Ammonia(NH_3)**: - Chemical ammonia (N) – a compound of nitrogen and hydrogen produces Ammonia pollution which is a byproduct of agriculture and industry.
- **Ozone (O_3)**: - Ground-level ozone forms just above the earth's surface are a colorless and highly irritating gas. When two primary pollutants react in sunlight and stagnant air produces "secondary" pollutants. These nitrogen oxides (NOx) and volatile organic compounds (VOCs) are two primary pollutants.

Here the analysis has been done in two parts:

- Analysis of the pollution level in India, over the years - from 2015 to 2020

This will give a holistic view of how the pollutant levels have been rising in India and what is the current situation.

- Effect of Lockdown on the Pollution level in India

Before and after the first stage of Lockdown pollution level in India should be examined. Also, we shall compare the pollution level around the same months in 2019, to see the difference, if any.

To get a fair idea of the effect of Lockdown on the Indian pollution level analysis of different categories could help.

On March 25, 2020, to reduce the spread of the COVID-19 disease the Indian government placed its population of more than 1.3 billion citizens under lockdown in an effort. Except for essential services including water, electricity, and health services all non-essential shops, markets, and places of worship were closed.

Citizens started to experience better air quality so much so that the scenic Dhauladhar Peaks of Himachal Pradesh became visible from neighboring states. On normal days, these peaks lie hidden behind the film of smog.

Fig -2: Dhauladhar Peak, Himachal Pradesh, (view from other neighboring states) during lockdown

Fig -3: India Gate, Delhi, left side before lockdown and right side after lockdown

2.UNDERSTANDING INDIAN AIR QUALITY INDEX(AQI)

The ministry of environment and forests launched a National Air Quality Index (AQI) [12] in an attempt to make air quality measurements easier to understand. It will put out real-time data about the level of pollutants in the air and inform people about possible impacts on health.

The air quality index has been classified as good, satisfactory, moderately polluted, poor, very poor, and severe with an increasing value of AQI. Each band is represented by a color code to visually express the level of severity that people can grasp easily.

Table -1: AQI Table

AQI	Remark	Color Code	Possible Health Effects
0-50	Good		Minimal impact
51-100	Satisfactory		Minor breathing discomfort for sensitive people
101-200	Moderate		Breathing discomfort to the people with lungs asthma and heart diseases
201-300	Poor		Breathing discomfort to most people on prolonged exposure
301-400	Very Poor		Respiratory illness on prolonged exposure
401-500	Severe		Affects healthy people and seriously impacts those with existing diseases

2.1 WHAT IS AQI?

Let's assume AQI runs from 0 to 500. With the increase of AQI value [13] level of air pollution and the health concern also increases. For example, an AQI value over 300 represents hazardous air quality while an AQI value of 50 or below represents good air quality.

AQI values at or below 100 are not very unhealthy. When AQI values go above 100, air quality becomes unhealthy, primarily for certain sensitive groups of people, then for the entire population.

The AQI is divided into six categories. Each category also has a specific color. The color makes it easier for people to determine if air quality approaches unhealthy levels in their surroundings.

2.2 Analysis

Each pollutant level in some important cities of India are shown below (Exploratory analysis on the Kaggle Dataset):

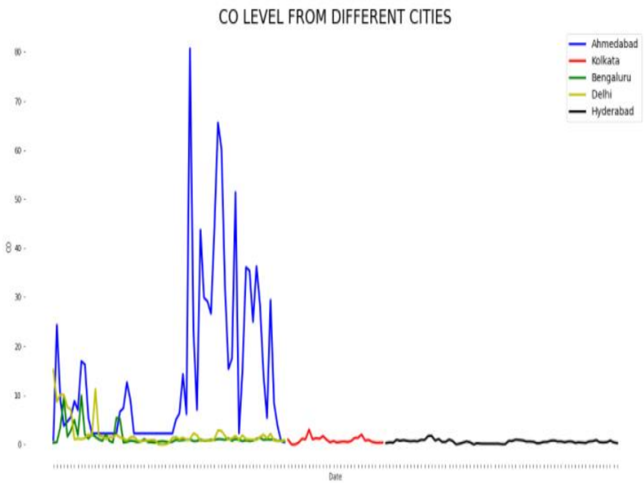


Chart -1: CO level from different Indian cities (Ahmedabad, Kolkata, Bengaluru, Delhi & Hyderabad) (Before Lockdown)

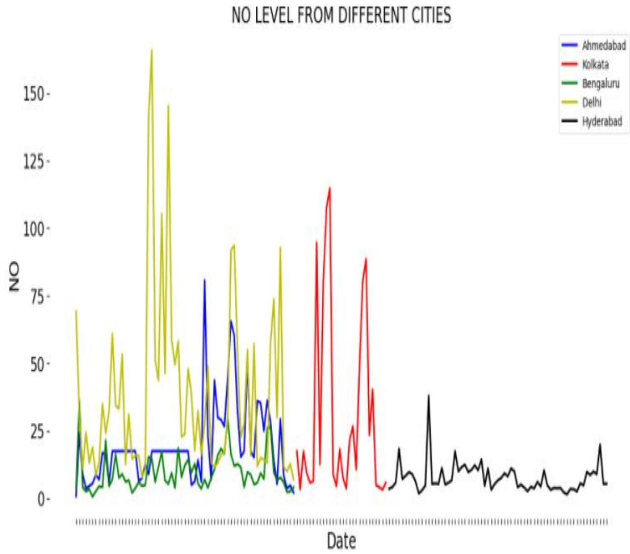


Chart -2:NO level from different Indian cities (Ahmedabad, Kolkata, Bengaluru, Delhi & Hyderabad) (Before Lockdown)

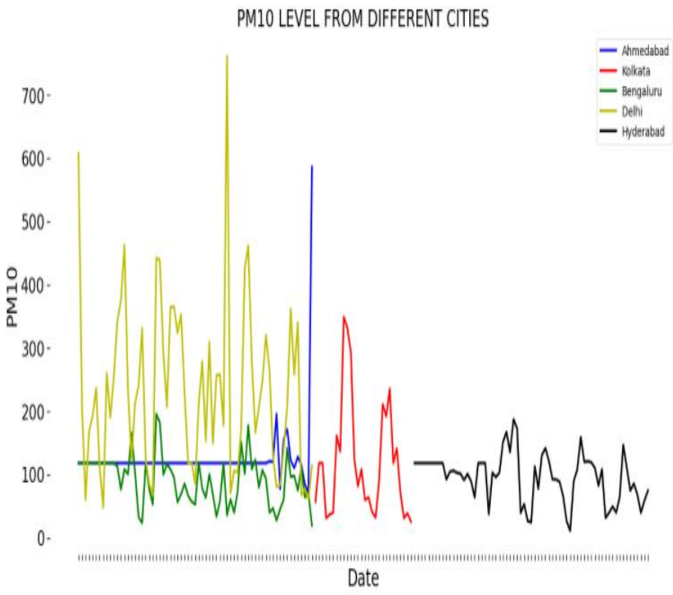


Chart -3:PM10 level from different Indian cities (Ahmedabad, Kolkata, Bengaluru, Delhi & Hyderabad) (Before Lockdown)

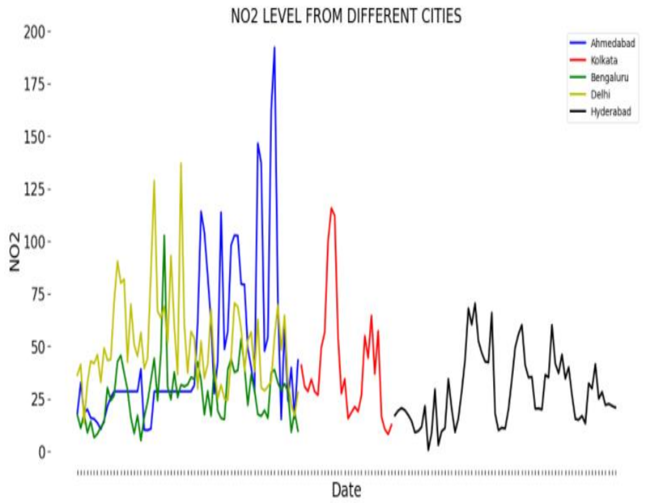


Chart -4:NO_2 level from different Indian cities (Ahmedabad, Kolkata, Bengaluru, Delhi & Hyderabad) (Before Lockdown)

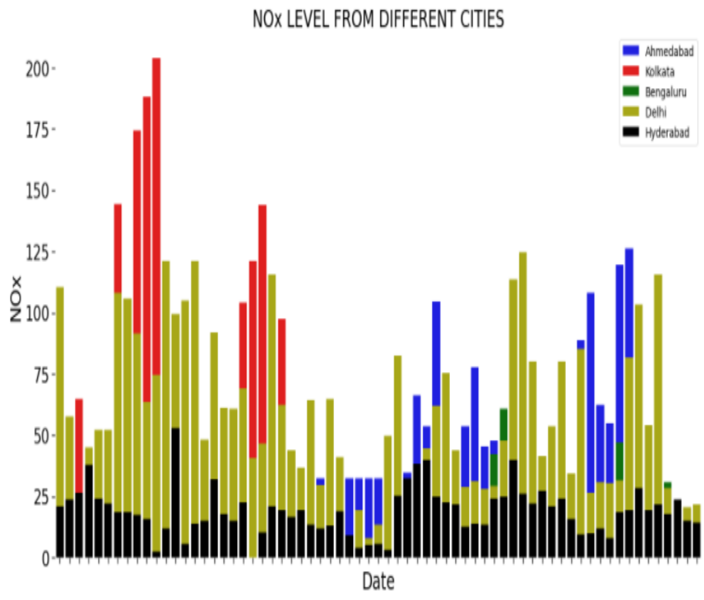


Chart -5: NOx level from different Indian cities (Ahmedabad, Kolkata, Bengaluru, Delhi & Hyderabad) (Before Lockdown)

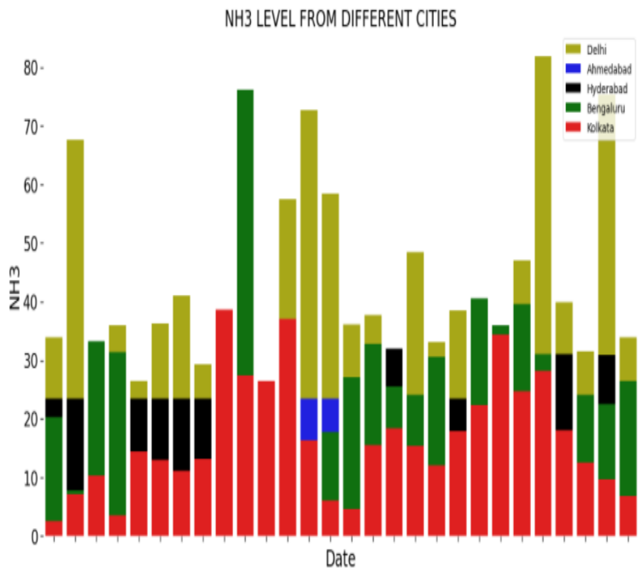


Chart -6: NH_3 level from different Indian cities (Ahmedabad, Kolkata, Bengaluru, Delhi & Hyderabad) (Before Lockdown)

So the average pollution level can be shown as below:

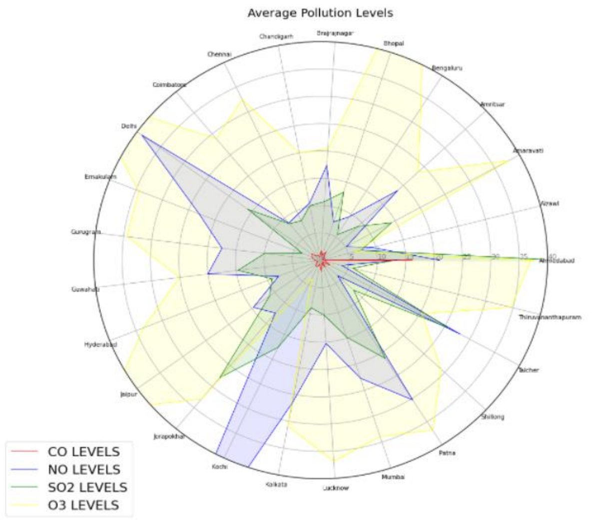


Chart -7: Showing CO, NO, SO_2& O_3 level

3. IMPACT OF CORONAVIRUS ON INDIA's AQI

Air Quality Index Comparison 2019 vs. 2020:

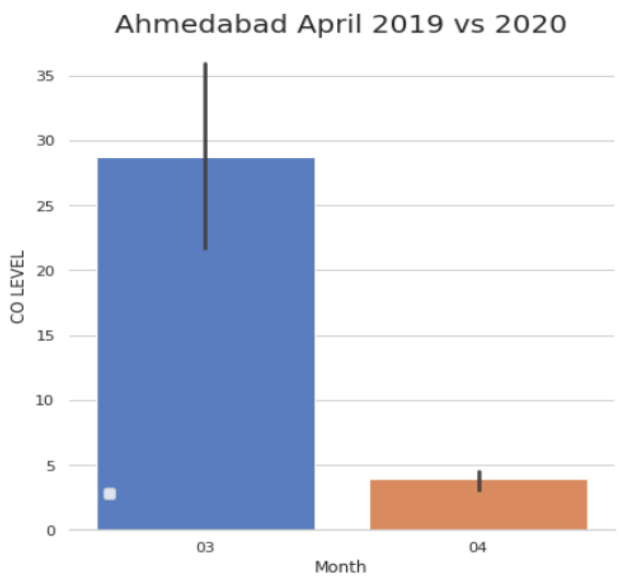


Chart -8: Comparison of CO level previously(blue) and during pandemic(orange) in Ahmedabad (Indian city)

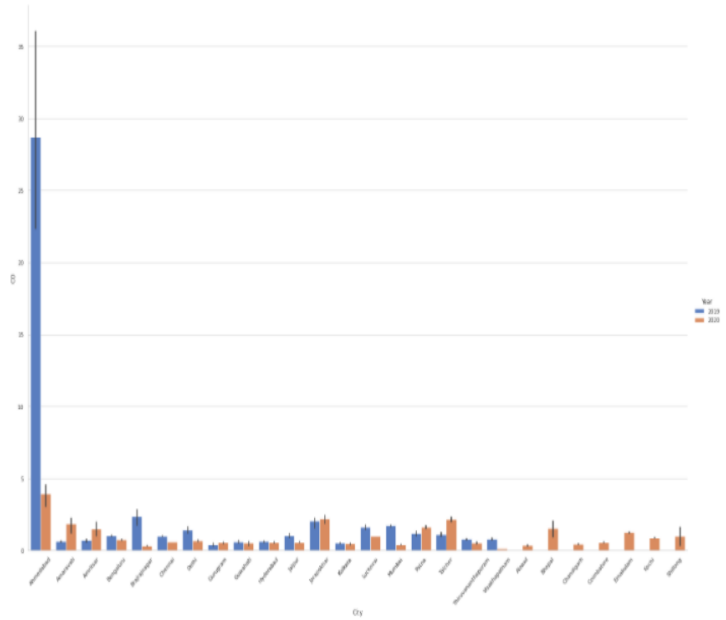


Chart -9: Showing the level of CO in different cities of India before pandemic (blue) and after pandemic (orange)

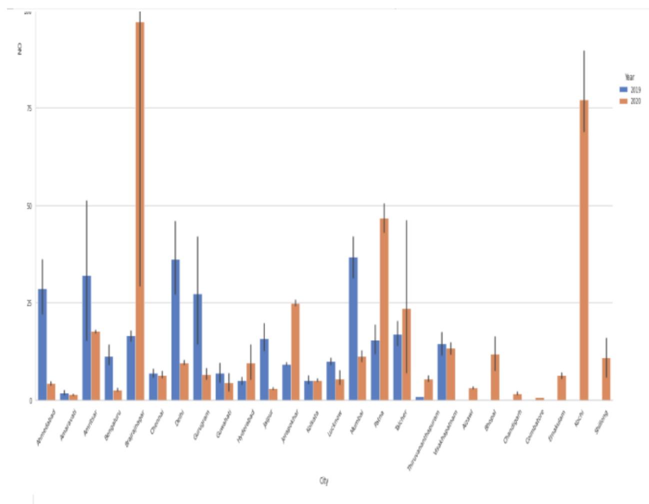


Chart -10: Showing level of NO in different cities of India before pandemic (blue) and after pandemic (orange)

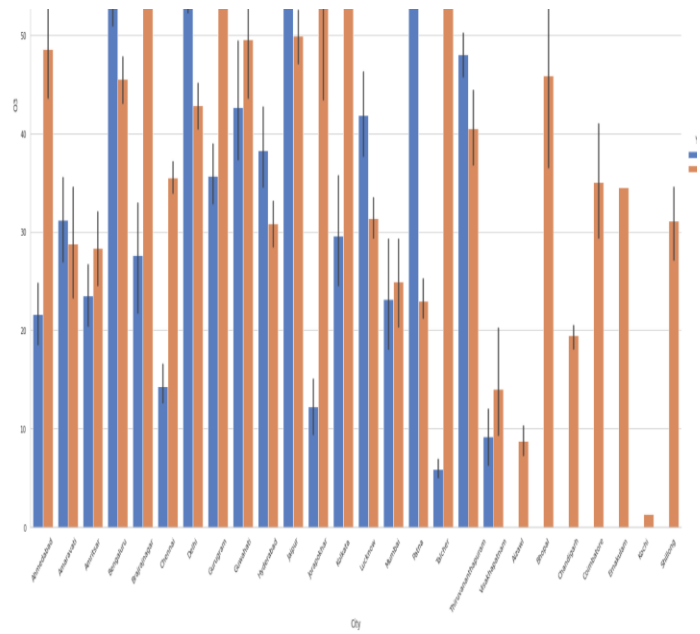


Chart -11: Showing level of O_3 in different cities of India before pandemic (blue) and after pandemic(orange)

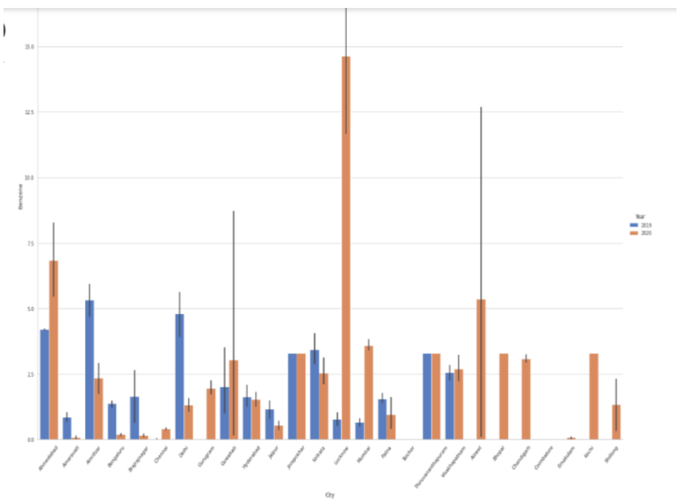


Chart -12: Showing the level of Benzene in different cities of India before pandemic (blue) and after pandemic(orange)

City / Date	Ahmedabad	Amaravati	Bengaluru	Brajrajnagar	Chennai	Delhi	Gurugram	Hyderabad	Jaipur	Lucknow
2019-04-01 00:00:00	353.000000	102.000000	126.000000	190.000000	130.000000	153.000000	114.000000	106.000000	109.000000	137.000000
2019-04-02 00:00:00	679.000000	92.000000	136.000000	193.000000	126.000000	194.000000	161.000000	114.000000	109.000000	204.000000
2019-04-03 00:00:00	688.000000	58.000000	135.000000	268.000000	117.000000	208.000000	183.000000	106.000000	125.000000	291.000000
2019-04-04 00:00:00	1044.000000	76.000000	127.000000	307.000000	89.000000	260.000000	187.000000	102.000000	128.000000	336.000000
2019-04-05 00:00:00	537.000000	78.000000	130.000000	305.000000	100.000000	284.000000	260.000000	93.000000	144.000000	315.000000
2019-04-06 00:00:00	420.000000	91.000000	130.000000	166.463581	101.000000	269.000000	282.000000	89.000000	137.000000	232.000000
2019-04-07 00:00:00	534.000000	124.000000	127.000000	166.463581	99.000000	315.000000	312.000000	78.000000	132.000000	195.000000
2019-04-08 00:00:00	472.000000	75.000000	125.000000	166.463581	98.000000	284.000000	320.000000	80.000000	457.000000	153.000000
2019-04-09 00:00:00	493.000000	73.000000	149.000000	166.463581	112.000000	240.000000	243.000000	91.000000	199.000000	155.000000
2019-04-10 00:00:00	566.000000	101.000000	123.000000	166.463581	111.000000	263.000000	247.000000	100.000000	140.000000	197.000000
2020-04-01 00:00:00	153.000000	69.000000	64.000000	148.000000	75.000000	80.000000	81.000000	87.000000	79.000000	116.000000
2020-04-02 00:00:00	164.000000	59.000000	70.000000	160.000000	74.000000	78.000000	81.000000	88.000000	71.000000	115.000000
2020-04-03 00:00:00	173.000000	59.000000	82.000000	158.000000	72.000000	84.000000	95.000000	73.000000	74.000000	81.000000
2020-04-04 00:00:00	182.000000	55.000000	74.000000	164.000000	67.000000	90.000000	93.000000	67.000000	76.000000	71.000000
2020-04-05 00:00:00	152.000000	51.000000	77.000000	139.000000	66.000000	103.000000	99.000000	66.000000	79.000000	91.000000
2020-04-06 00:00:00	145.000000	39.000000	65.000000	129.000000	57.000000	134.000000	106.000000	64.000000	79.000000	90.000000
2020-04-07 00:00:00	159.000000	30.000000	62.000000	166.463581	55.000000	100.000000	94.000000	77.000000	80.000000	75.000000
2020-04-08 00:00:00	183.000000	38.000000	67.000000	166.463581	55.000000	91.000000	96.000000	56.000000	78.000000	77.000000
2020-04-09 00:00:00	168.000000	52.000000	65.000000	166.463581	55.000000	89.000000	101.000000	59.000000	78.000000	94.000000
2020-04-10 00:00:00	113.000000	53.000000	76.000000	236.000000	80.000000	111.000000	105.000000	62.000000	76.000000	81.000000

Chart -13: Air Quality Index Comparison 2019 vs 2020 (April 1st 10 days)

So, after analyzing the whole scenario, basically the charts, we can conclude that due to the COVID outbreak causing a lockdown, the air pollution level went down. So, everything has some pros and cons. Now let us discuss the monitoring system which monitors the AQI level.

4. MONITORING SYSTEM

"Internet of Things (IoT)"[1][2] includes traditional computing devices like laptops, tablets, and smartphones with other devices that also have internet-enabled functions. Examples: security cameras, home appliances, wearable electronics, automobiles, and loTs of other things. A device to be part of the Internet of Things must have the capability to communicate with other devices. Therefore, some sort of built-in wired or wireless communication is required. Most IoT devices are Wi-Fi enabled, but Bluetooth also can be used to transfer data to nearby devices. As IoT devices can communicate with other things, an array of sensors that provide useful information known as "smart devices" are used. In this project, we are using sensors with which it can provide some information about the Air Quality Index for future use.

4.1 METHODOLOGY

4.1.1 WORKFLOW

PHASE - 1: Detection of Air Pollutant Level

It indicates the early phase of the project. An IoT-based kit is developed which can detect air pollution. It deals with the collection of data from gas sensors connected to Raspberry Pi and the information is sent to the cloud platform that stores it.

PHASE - 2: Creating the interface

This stage involves components for optional performance clarification. MCP3008 calibrated to convert analog data to digital with onboard sample and hold circuitry. Mobile Applications could be used to collect data, store, process, and monitored. The Users can review the stored data through the application.

PHASE - 3: Execution and Testing

The project deliverables are built with the help of different circuit designs with various components interfaced together to test the performance of the design under various conditions testing, debugging and troubleshooting of the design is performed. A new circuit design should be completed, implemented, and tested only If the former one fails.

4.1.2 HARDWARE REQUIREMENT

1) **Raspberry pi 3: RASPBERRY PI 3** is a PI series development [10] board in. It is single board compatible with Linux OS (Operating System). Nowadays it is used for advanced applications It is specifically designed for people who are interested in Linux OS and IoT.

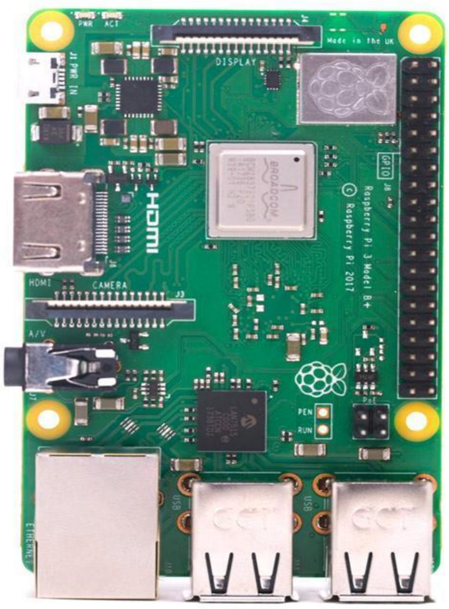


Fig – 4: Raspberry pi 3

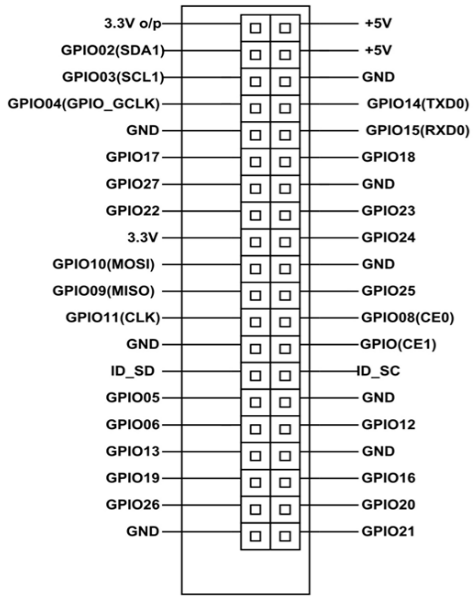


Fig – 5: Schematic Diagram of Raspberry pi 3

2) **MQ2 sensor:** An electronic sensor MQ2 gas sensor is used for sensing the concentration of LPG, propane, methane, hydrogen, alcohol, smoke, and carbon monoxide.

Fig – 5: MQ Sensor used for sensing

3) **MQ7 sensor: MQ-7** is a Carbon Monoxide (CO) **sensor** used to sense Carbon Monoxide concentrations (PPM) in the air. The **MQ-7 sensor** can detect CO concentrations ranging from 20 to 2000ppm. This fast responsive and high sensitivity **sensor**. The **sensor's** output is an analog resistance.

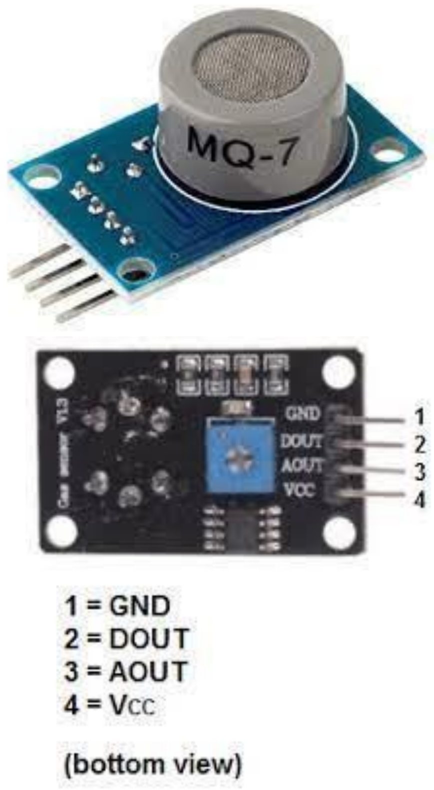
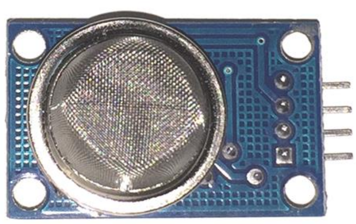


Fig – 6: MQ-7 Sensor

4)**MQ135:** Air quality **sensor** detects different gases like NH_3, NOx, alcohol, benzene, smoke, and CO_2. **MQ135** gas **sensor** has a high sensitivity to Benzene steam, Ammonia, Sulfide, smoke, and other harmful gases.



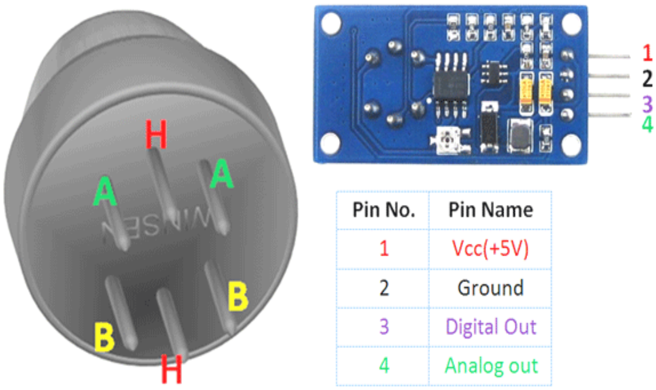
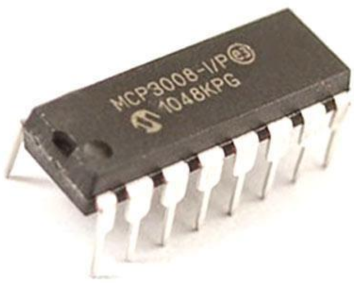


Fig – 6: MQ-135 Sensor

4) Power supply

5) **MCP3008:** The **MCP3008** is an **8-Channel 10-bit ADC IC**, so it can measure 8 different analog voltages with a resolution of 10-bit. It measures the value of analog voltage from 0-1023 and transfers the value to a microprocessor or microcontroller through **SPI communication**. It can be used with 3.3V systems Raspberry Pi as well as with a5V microcontroller. It converts the analog voltage to a digital value using the SAR method; It is the cheapest and easiest to use one. This is an ADC **IC** with a resolution of 10-bit (0-1023) with 8-channels with a decent speed. In Raspberry Pi, It is very commonly used.



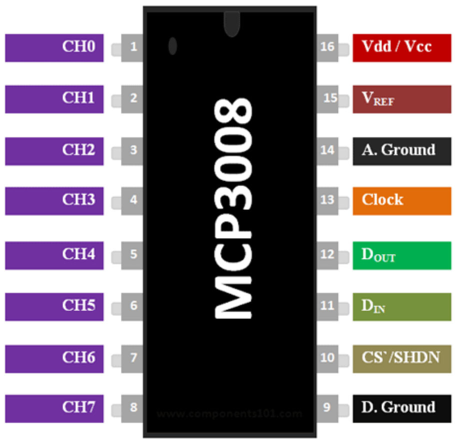


Fig – 7: MCP3008

6) 16GB memory

4.1.3 SOFTWARE REQUIREMENT

1) Raspberry pi3 - Raspian OS
2) Python
3) Front end: PHP
4) Back end: MySql

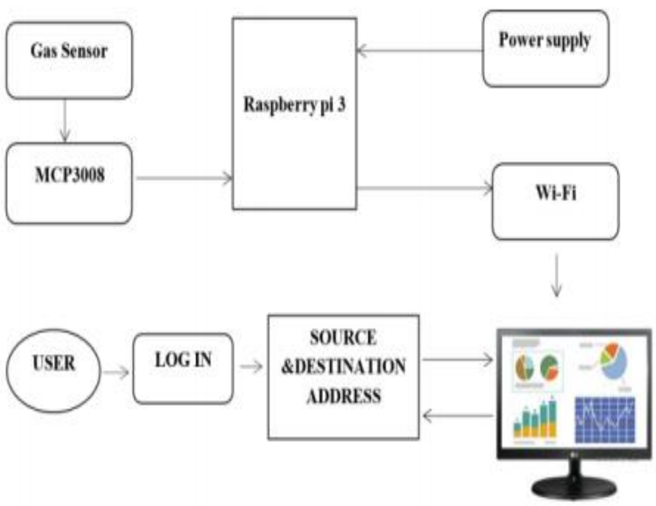


Fig – 8: BLOCK DIAGRAM OF IMPLEMENTATION

4.1.4 HARDWARE IMPLEMENTATION

The hardware implementation requires a Raspberry Pi. The ESP8266 Wi-Fi Module is a self-contained System On Chip (SOC)that can give any microcontroller access to your Wi-Fi network. MCP3008 is a 10-bit Analog-to-Digital Converter (ADC) with low power consumption and high performance, making it useful for embedded control applications. MQ-2 Gas Sensor can measure gases like LPG, Alcohol, Propane, Hydrogen, CO, and even Methane. MQ-7 Gas Sensor detects CO concentrations in the air anywhere from 20 to 2000ppm and it also makes detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V). These sensors' conductivity is higher along with gas concentration rising.

STEP 1: Installation of Raspbian OS in Windows operating system
STEP 2: Open IDLE and create a new sketch by clicking programming.
Programming Language: Python 3(IDLE).
STEP 3: Write a program.

4.1.5 SOFTWARE IMPLEMENTATION

The software implementation provides the creation of an API. User needs to sign in to the application
1. by providing the specified details.
2. For access, a user must log in to the application by providing the credentials
3. When the user feeds the source and destination details and clicks "NEXT" the application displays the level of pollutants he is exposed to.

5. RESULT & CONCLUSIONS

5.1 Comparison between before lockdown and after lockdown

As a result, our endeavor is to check the quality of the exposure level in air pollution. The mobile application is developed by getting the source and destination address from the user. In this application, it monitors the pollutant level in that way. It also tracks the individual's exposure level to air pollutants for a single day. Our work was designed to help a person detect, monitor, and test air pollution in a given area. The kit has been integrated with a mobile application that helps the user.

This proposed air pollution monitoring kit along with the integrated mobile application can be helpful to people to identify their exposure level to air pollutants. The app had the following features, indices of air quality using real-time computation, air quality daily reports based on users' travel distance, specific reports for air quality measures based on locations. Air Pollution is the major affecting factor to our environment. Not only does it affect the environment but also affects human health. The mobile application is developed to monitor how much the human has exposed in a day. The gas sensors were used for identifying the Leakage Gas, Carbon Monoxide, Smoke, and propane. The sensor senses the gases and converts them from analog to digital and displays them in the application. The exposed level is calculated in PPM (Parts per Million)

Based on measurement of particulate matter (PM2.5 and PM10), Ozone (O_3), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), and Carbon Monoxide (CO) emissions Air Quality index is calculated. PM2.5 and PM10 data are monitored in most of the stations, but PM10 is available in few stations.

ACKNOWLEDGMENT

The data has been made publicly available by the Central Pollution Control Board: https://cpcb.nic.in/ which is the official portal of the Government of India. They also have a real-time monitoring app:
https://app.cpcbccr.com/AQI_India/

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