

INTERNET OF THINGS BASED AIR POLLUTION PREDICTION AND MONITORING SYSTEM

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ABSTRACT

With urbanization demand for factories and vehicles increased exponentially. Resources are excessively used by human beings for comfort and development. The Burning of fossil fuels in factories and industries caused air pollution due to which different type of cardiovascular and respiratory diseases occurs to us. Air pollution by vehicles is also a major problem because the growth of vehicles increasing every year. Air quality is degrading rapidly with the increase of air pollution and it affects the human health, plants life and animals. All urban cities of world are facing problems related to climatic changes and poor air quality. Increase in industries, forest fires, burning of fuels, nuclear weapons are major factors for responsible to degrade air quality. The Major part of air pollution is because people using private transport. Due to this resources are burning rapidly and air pollution increased. Nowadays most of countries are developing smart cities to provide safe and healthy life to peoples. In this paper we discussed problems caused by air pollution and how can we monitor it by using the internet of things. We use gas sensors and dust sensors which are placed in traffic signals which are used for sensing the data. Arduino is used for analyzing data and data is stored in the cloud. People can get information by using the android application.

Keywords: Health effects; IoT platform; Sensor calibration; Alarming unit

I. INTRODUCTION

The basic requirement of human beings is a good quality of air because we inhale approximately 10,000 liters of air in 24 hours. Air pollution is mainly caused in traffic signals by vehicles due to zero movement. Due to Air pollution all urban cities and developing cities faced so many problems. The

basic need of human is good air quality. It is a mixture of useful gases and gases which is harmful to health. When the level of harmful Gases increased above a safe level then it causes harm to humans, Plants, and animals. Air pollution causes many problems related to health, which not treated with in time results serious problems. [1] The risk of health is increasing day by day due to contamination of air. Diseases such as lung cancer, asthma, pneumonia, bronchitis, coronary artery, eye irritation, pores and skin diseases are caused due to chemical pollution so it is very important to control pollution by using an Air pollution monitoring system based on IoT. Six pollutants which are responsible for premature death are carbon monoxide, ground stage ozone, lead sulfur oxides, nitrogen oxides and particle pollution [2]. Kitchen waste, vehicles, construction, industries, factories etc. are indoor and outdoor element which causes air pollution and very harmful for health. Air pollutants are also responsible for damaging ozone layer. Due to which cosmic rays can easily affects human health's. Population and Industries are also increased with the increase in urbanization. Mainly Industries cause serious problems to the environment. Nowadays the quality of air is continuously degrading. With the help of real-time monitoring of air, we can check it from time to time. [4] Due to the increase in population and urbanization, there is a tremendous increase in air pollution. For economic development, automobiles industries are necessary to a country but in terms of air pollution, these industries cause hazardous problems. Air pollution caused by four-wheeler vehicles is more compared to two vehicles due to the emission of pollutants. To control air pollution due to vehicles we can use electric vehicles. [5] Nowadays developing countries works on smart cities project. The major goal to develop smart cities is to provide healthy and safe atmosphere to peoples. So there is an emerging need to develop wireless sensors network system using internet of thing which can predict and monitor the air pollution by transferring data to cloud. People can know the status of air pollution by using android application. It can help in reducing air pollution because people can divert there route or postpone their journey. [32]

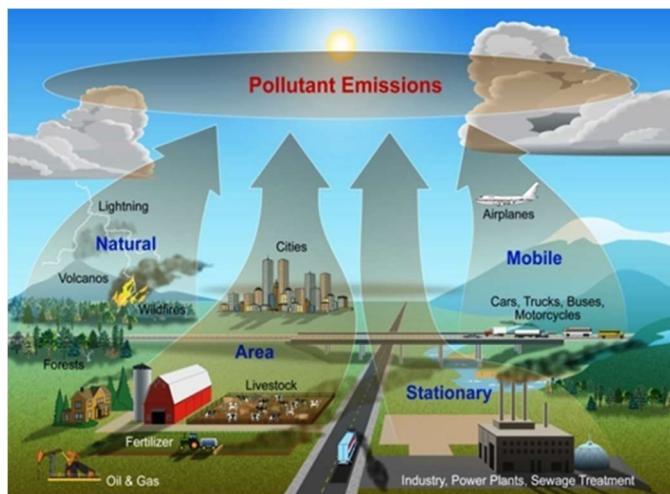


Figure 1. Sources of Air Pollution

II. PROBLEM STATEMENT

Due to air pollution, around 1.2 million peoples die every year. Premature death also occurred due to air pollution. Every year there is an increase in the number of vehicles due to which emission by the vehicles also increased. People are still using old vehicles due to which many problems occur and also cause air pollution. Peoples die every year. Premature death also occurred due to air pollution. Every year there is an increase in the number of vehicles due to which emission by the vehicles also increased. Global warming, acid rain, smog, and damage to the ozone layer are also the result of air pollution. The major threat to the country is air pollution emitted by vehicles. [5] The concentration of pollutants in the air is increasing regularly because of industries and transport. According to the world Health organization 9 out of 10 peoples breathes polluted air. Due to the respiration of polluted air, people get health disorders. Respiratory problems, cardiovascular problems, and premature death are major problems caused by air pollution. Air pollution is hazardous among all types of pollution. [9]

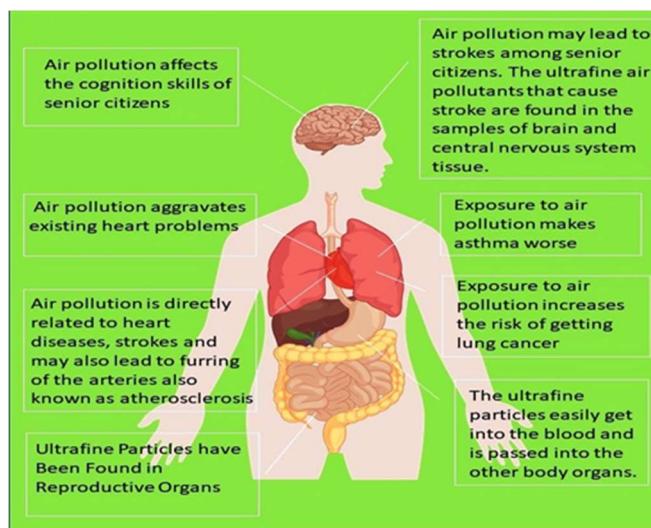


Figure 2. Effects of Air Pollution in human being

III. AIR QUALITY AND AIR QUALITY INDEX

Air is a mixture of gas which is colorless, tasteless and odorless. Air is very important for human, plant and animals. Water is also important for human but without water a person can live for few days but without air he cannot live for few minutes. Pure air means about 78% nitrogen, 21% oxygen, and less than 1% argon. The Good quality of air is which is clean and free from air pollution. When unwanted particles, chemicals etc. mixed with pure air and harmful for human beings, plants and animals than it considered as air pollution. Millions of people inhale pollutants emitted by different vehicles. Nowadays in an urban area, the standard quality of air is not present due to air pollution which causes several problems to animals, plants, and humans. When outer materials such as CO and CO₂ are mixed with air it causes air pollution. If the quality of air becomes poorer than it can irritate eyes, nose, and throat, shortness of breath, other respiratory diseases, heart diseases and cardiovascular diseases. [6] [32] The Air quality index is the scale that

is used to measure the quality of air whether it is good, bad, or severe. To know the air quality in an urban area and Cities air quality index is very important. The Quality of air becomes poorer if the AQI value is increased. Dust sensors and gas sensor is used to calculate AQI. Air quality index is used measure that how air pollution affects the health. [4]

AQI	Category	Health Impacts
0-50	Good	Minimum
51-100	Moderate	Minor discomfort in breathing
101-200	Poor	Breathing discomfort to those people having lungs and heart disease.
201-300	Unhealthy	Breathing discomfort to most.
301-400	Severe	Respiratory illness.
401-500	Hazardous	Affects Healthy people also.

Table 1 AQI and their health impact

IV. POLLUTANTS

Among all types of pollution air pollution is hazardous and should be noticeable. It is a hard job to eliminate air pollution. Respiration is very necessary for human beings and animals that's why it directly affects humans and animals.

Primary pollutants and secondary pollutants are two types of pollutants. Those pollutants are emitted from factories and exhaust pipes and are directly produced in the atmosphere while secondary pollutants are formed due to chemical reactions in primary pollutants. [9] Forest fires and volcanic ash are an example of primary air pollutants. The emission of carbon monoxide from vehicles is also a primary pollutant.

A. Carbon dioxide (CO₂)

It is a greenhouse gas which is generated during respiration, Combustion of coal, etc. Productivity of agricultural land is affected due to high level of CO₂. Temperature of environment also included due to high level of CO₂.

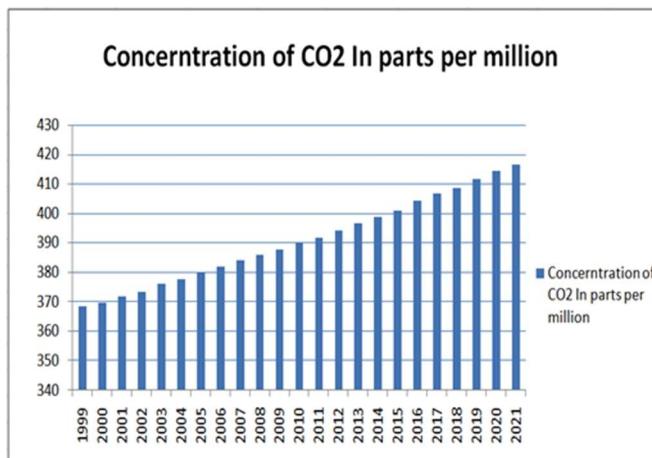


Figure 3. Average CO2 Levels in the atmosphere from 1999 to 2021

B. Methane

The main source of emission of methane is oil and gas industries. It is also produced during production of coal. Waste material decomposition and due to Agriculture methane is emitted. It is very poisonous in gaseous state. Oxygen level is reduced due to high level of methane and causes suffocation. Methane in liquid state cause skin disease named frostbite.

C. Ammonia

Ammonia is produced due to decomposition of organic material such as human waste. Ammonia causes eutrophication and acidification in environment. It causes irritation to skin, nose, skin and throat when it comes in contact to human body.

D. Nitrogen dioxide.

It is highly poisonous gas. It is mainly produced due to burning of fuels from power plants, vehicles etc. It directly affects the respiratory system which causes several diseases related to respiration.

E. Sulfur dioxide

In atmosphere sulfur dioxide is in higher concentration in comparison of other oxides of sulfur. In Industries and Power plants burning of fossil fuels produced sulfur dioxide which is main source. In air it easily reacts with other compound and formed harmful compound such as sulfurous acid and sulfuric acid. If sulfur dioxide is present in air it affects the health of human beings. Sulfur dioxide irritates nose and throat. When human beings inhale sulfur dioxide than breathing becomes major problem.

F. Nitric oxide.

Nitrogen and oxygen combines to make nitric oxide. It is major component of air pollution. Hydrocarbon fuel and air is burned in power plant and in internal combustion engine than in high temperature inactive nitrogen combines with oxygen to form nitric oxide. Acid rain is caused by the high concentration of nitric oxide. It also affects the plants.

G. Dihydrogen.

When two hydrogen atoms combine together than dihydrogen is formed. Burning of biomass, fossil fuel combustion, oxidation of non-methane, oxidation of hydrocarbon, oxidation of non-

methane and photolysis of formaldehyde. It is used as a coolant. Acid rains and Greenhouse effects are caused due to high concentration of dihydrogen.

H. Phosphine

When chemical reaction between calcium phosphide and water takes place than phosphine is formed. It works as pesticide on tobacco stored and animal feed. Fatigue, Cough, vomiting, headache etc. is health problems caused due to phosphine.

I. Ozone

When three atoms of oxygen combine together than ozone is formed. The first layer of ozone protects the earth by ultraviolet rays. The second layer of ozone is present in ground level of earth and it causes air pollution. Ozone affects eyes, respiratory tracts and lungs.

Table 2 Pollutants and Sources

Pollutants	Source	Effects
PM 2.5	Mining and combustion engines	Respiratory Problems, decreased lung functions
Ground Level Ozone	Emission from industrial facilities and electric utilities	Asthma, cough, shortness of breath
Nitrogen dioxide	Fuel combustion	Coughing, cold, flu and Bronchitis, impaired visibility
Carbon monoxide	Fuel combustion	Suffocation, reduced blood oxygen
Sulfur dioxide	Fuel combustion, industrial smoke	Nausea, Vomiting, diarrhoea, stomach pain
Lead	Paint	Lead poisoning, stunted brain development

J. Photochemical Smog.

It is a type of secondary air pollution. Nitrogen dioxide splits in the presence of sunlight and releases oxygen ions. The oxygen molecule bonds with oxygen ions and forms ozone. Ozone is a component of photochemical and also a greenhouse gas.

Figure 4. Photochemical Smog

V. OUTDOOR AND INDOOR POLLUTION

The burning of fuel and gases such as carbon monoxide, SO₂, and ozone results outdoor Air pollution. Household chemicals, smoke, sulfur oxide, and carbon causes indoor air pollution. When gases and particulate matter pollutant mixed with pure air and degrade the quality of indoor air resulting indoor air pollution. Indoor air pollutants come from cooking with wood, cooking with charcoal, smoking, smoke from stoves. If we want to protect the ecosystem, and then air pollution levels should be continuously monitored. As we know smart cities are big projects nowadays but we have to monitor air pollution using IoT. [10] traditionally air pollution monitoring systems are very expensive.[13]

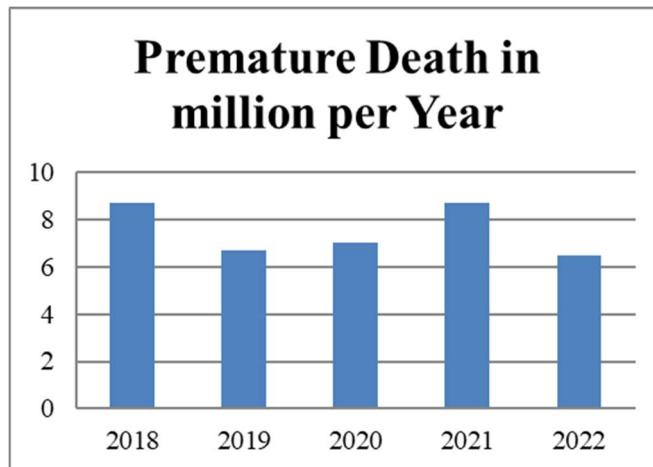


Figure 5. Premature deaths per year in world Calibration

VI. CALIBRATION

To ensure the quality of data in the existing air pollution monitoring system, there is a need for Calibration. Calibration of the sensor should be done before and after the deployment of air pollution sensors. To ensure the quality of data periodic calibration should be done in low-cost sensor air pollution monitoring systems. Post deployment calibration of sensor to remove errors and to maintain consistency. Sensor calibration is necessary to improve the data quality and to remove errors. Before deployment of sensor in field it is necessary to predeployment calibration to reduce the internal and external errors. With the time there is chance of error in air pollution monitoring system than it is necessary to post deployment calibration of sensor to reduce errors. Blind calibration is a concept to make similarity between measurements of all sensors. This calibration is based on assumption that neighboring sensor also measure identical values. To calibrate temperature and humidity data sensor array calibration is used.[13] The calibration of the CO sensor is done with the help of collocated accurate, reference sensors by comparison to this reading. [14] The device should be calibrated in the fresh air and the final program is fed. To calibrate the device in fresh air we take CO₂ level as a reference and left the device in fresh air for 24 hours in working mode [15].

VII. PROPOSED MODEL

Gas sensors (MQ135& MQ7) and dust sensors (GP2Y1010AU0F) are placed in traffic signal which detects the fumes released by vehicles. Data that is sensed by sensors are transferred to the Arduinouno, the sensed data is in an analog form then with the help of analog-digital converter data is converted to the digital form. Arduinouno can read data only in digital form. To calculate the Air quality index data is converted in form of PPM then data is transferred to the transmit pin of Arduino. Arduino is connected to the ESP8266 and alarming unit. If the Air quality is in bad condition, then data is sent to the alarming station and the alarm rings. Data is analyzed in the online server Things IoT platform. With the help of a mobile application in real time, data can be accessed whether the air quality is good, bad, or severe.

A. Wireless Sensor Network: -

Sensors are placed in field to detect the data and transfer it to air pollution monitoring system through microcontroller. The sensors are placed in the field are thousands in number for accurate results. In remote and inaccessible area wireless sensor network play a very important role to monitor air pollution. Using wireless technology sensor can transmit data to control system and sensor can be placed randomly in field. While the sensor is placed in open field than the life of sensor and consumption of energy is not good. [31]

B. Internet of things: -

It is a technique to connect a physical device with the help of the internet. Physical devices can sense information and transfer information. Using IoT technology sensed information is transferred to the management and uploaded information to the cloud. It helps in smart work and reduced labor cost. We can access information from anywhere using IoT. It is a platform used to store and retrieve data by using http protocol over the internet. It allows the data to be visualized and analyzed. [7] IoT platform manage connectivity between sensors and data networks. It helps in collect the data and transfer to another device wirelessly. With the help of Things IoT platform network system works together. IoT platform can easily detect which information is important and which one is not. Commonly used IoT platforms are Node red, Open remote, Flutter, M2MLabs Mainspring, Things Board, Kinoma, KaalIoT Platform, Site Where, DSA, Thinger Thing speakIoTplatform etc.

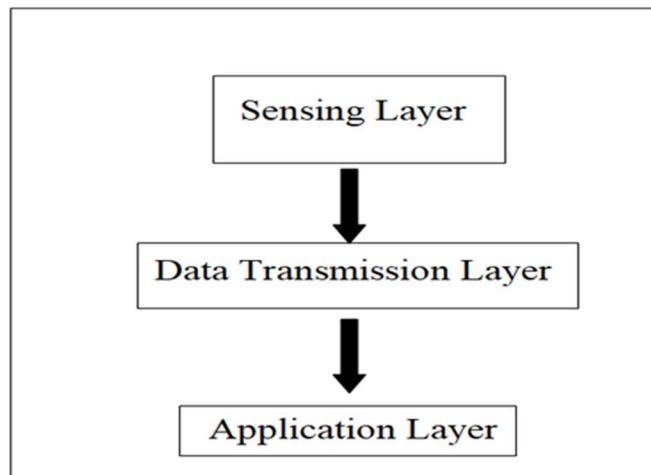


Figure 6. IoT Architecture

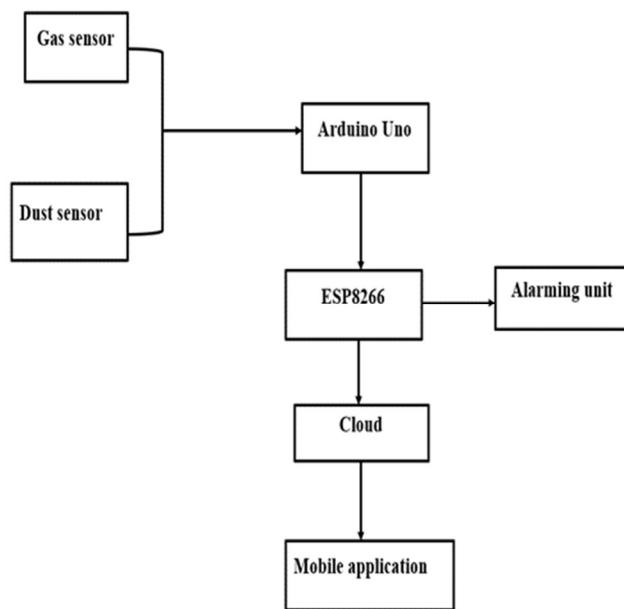


Figure 7. Flow chart of proposed model

C. Gas Sensor: -

The purpose of these sensors is used to collect the data from the environment and transfer it to the receiver. [3] Pollutants which are very harmful to human health are in gaseous form.

I. MQ7 Gas Sensor: -

This sensor contains 6 pins which 2 pins are used for fetching data .and 4 pins are used for the heating circuit. It is used to detect CO in analog form, using ADC it is converted into digital form.



Figure 8.MQ07 Gas Sensors

II. MQ135 Gas sensor: -

MQ135 Gas Sensor is used for detecting gases, such as NH₃, alcohol, benzene, smoke, and CO₂. It is very sensitive to NH₃, benzene, and other harmful gases. It consists of a steel exoskeleton in which a sensing element is fitted.



Figure 9.MQ135 Gas sensors

D. GP2Y1010AU0F Dust sensor: -

This sensor is used to detect particulate matter. This device is based on an infrared emitting diode and a phototransistor and it detects the light which is reflected from particles of air. This sensor can even detect smoke.



Figure 10.GP2Y1010AU0F Dust sensors

E. Arduino Uno: -

It is a microcontroller board which has 14 digital input/output pins, a USB port, a Power supply, and 6 analog input. The main work of Arduinouno is to sense the data from the sensor and provide it to the system.

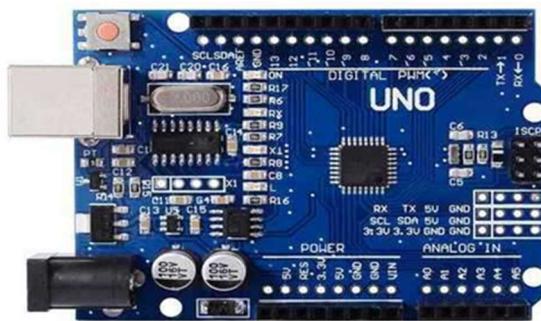


Figure11. Arduinouno

F. Analog to digital converter: -

This device plays an important role in this model. The data which is received from the sensor is in analog form but Arduino cannot read analog signal. Analog to digital converter is used to convert analog signal to digital signal.



Figure 12. Analog to digital converter

G. Microcontroller: -

This device plays an important role in this model. The data which is received from the sensor is in analog form but Arduino cannot read analog signals. Analog to digital converter is used to convert analog signal to digital signal.

Figure 13. Microcontroller

H. Algorithm

Input – Data are collected from various sensors and then these steps are taken to air pollution

If (pollutants > standard limit of pollutants)

Then {Alarming Station rings alarms the information and uploads the data to the cloud}

Else {upload data to cloud}

Output – we can control problems when air pollution increases and an alarming station ring an alarm.

VIII. RESULTS

Air pollution monitoring systems calculate the quantity of air pollutants. With help of Internet of things data send wirelessly to things speak channel. The concentration of gaseous air pollutants is shown in fig. 14 And dust air pollutants are shown in fig. 15.

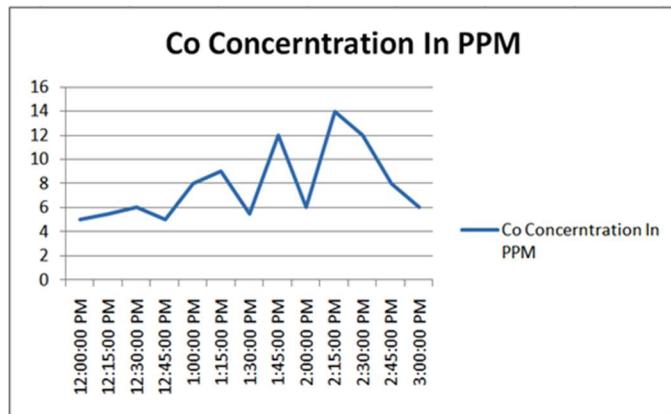


Figure 14. Concentrations of CO (PPM)

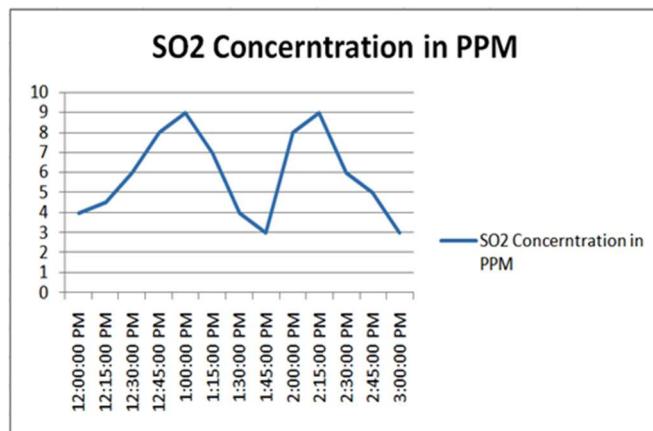


Figure 15. Concentrations of SO₂ (PPM)

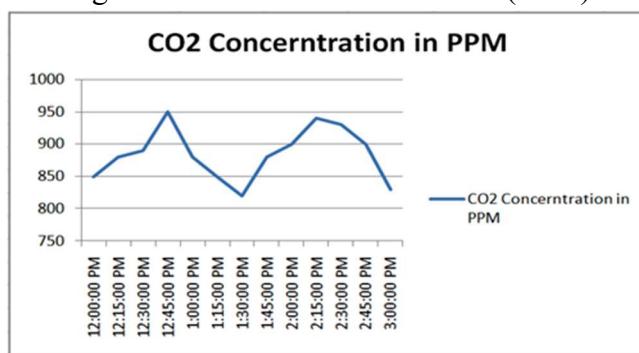


Figure 16. Concentrations of CO₂, (PPM)

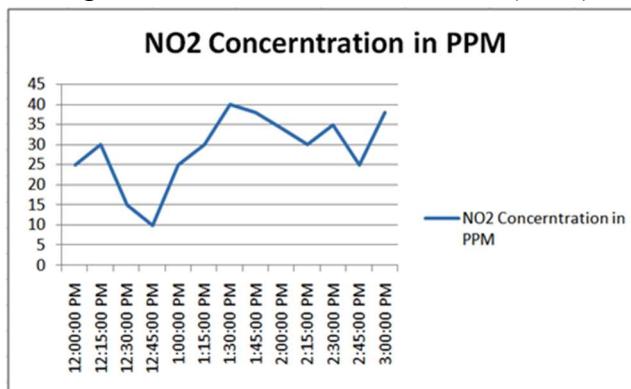


Figure 17. Concentrations of NO₂ (PPM)

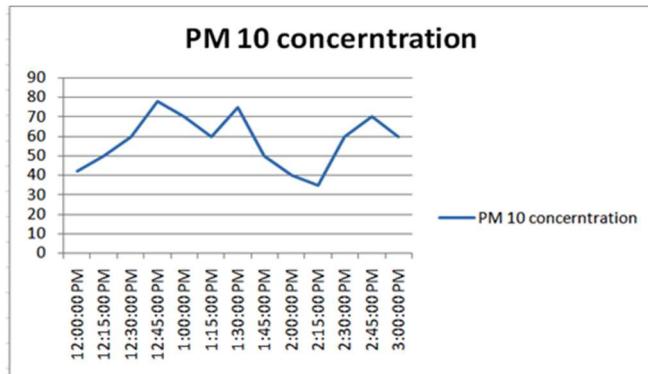


Figure 18. Concentrations of PM 2.5 and PM 10.

With the help MATLAB visualization tool we can determine the value of AQI. AQI is categorized in six categories i.e. good range (0-50), moderate range (51-100), poor range (101-200), unhealthy range (201-300), severe range (301-400) and hazardous range (401-500) with respective colors green, parrot, yellow, orange, red and maroon colors.



Figure 19. Received alert massage in good condition

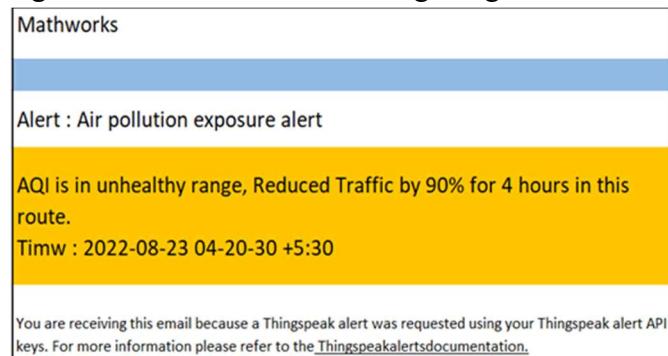


Figure 20. Received alert massage in unhealthy condition

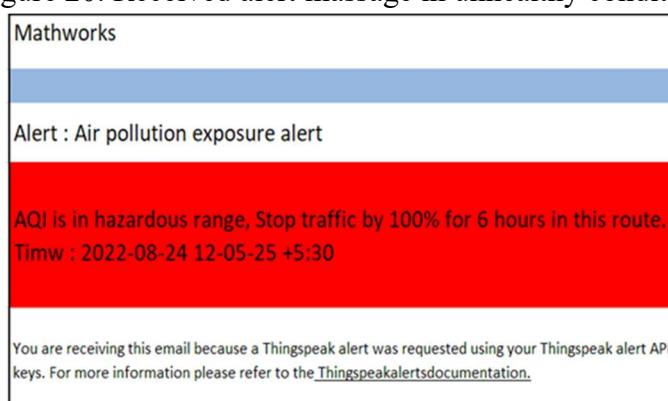


Figure 21. Received alert massage in hazardous condition

IX. GAPS IN EXISTING WORK

By using the Internet of things we can determine air pollution levels. But we have to solve it immediately. In cities, we can't motivate people to reduce private transport and it is also difficult to do cycling in this busy schedule of life. A major challenge is to reduce the cost of the monitoring system because the cost of batteries is high. Batteries should be replaced by solar power panels.

Security of sensors is not in moving vehicles. To get an accurate result of air pollution we have put the device secure.

X. CONCLUSION

Air pollution is a major problem because it is increasing exponentially and it should be noticeable among all types of pollution. The development of cities and urbanization are the main causes of air pollution. Premature death and many health issues are a result of air pollution. Air pollution directly affected the respiratory system because pollutants present in the air are very harmful to health. To save life and for a healthy life it is very important to predict and monitor the air quality. People should use public transport instead of private transport because in public transport more people can transport. We have to develop smart sustainable cities. To balance the ecosystem, we should grow more plants and we should stop deforestation. We should use cycles for short-distance transport. In this paper, we discussed air pollution monitoring systems using the Internet of Things. To save humans, plants and animals we should control air pollution.

XI. FUTURE WORK

The monitoring system is based on batteries. In the future, we can design a small and compacted monitoring system that can be based on solar power energy because sunlight is pure and contains no pollution.

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