Air Quality Monitoring System

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Abstract—**Air pollution is both an environmental and a social problem, as it leads to adverse effects on human health, ecosystems and the climate. Air pollution is one of the largest environmental health risks today. Quality of the air is the most important factor that directly influences the incidence of diseases and decreases the quality of life. Taking appropriate decisions in a timely period depends on the measurement and analysis of the parameters of the air, which creates the need for the development of real time air quality monitoring. The use of multiple parameters for air quality monitoring makes it possible to do a detailed analysis of major pollutants and their sources. These monitoring systems are important in many smart city projects for monitoring air quality and for controlling the main pollutant concentrations. This project paper describes the design and implementation of an Air Quality Monitoring System. The technology used in this project is a practical implementation of the concept of Internet of Things. This project is an exploration of use of the modern technology in a rapidly changing world where environmental health is becoming a serious threat. Using the Wi-Fi communication technology and microcontroller board of Arduino, node MCU the work is implemented. A few sensors are used such as temperature and humidity sensors and a few gas sensors to monitor changes.**

***Keywords*— Air quality; Pollution; Sensors; Arduino; Node MCU.**

I. INTRODUCTION

The changes in weather conditions and in the environment around us are undeniable reality. It is slowly but surely having adverse effects on our life and the things around us. With the recent increase in industrialization, release of poisonous material increases manifold substantially. The levels of toxic gases in the air are alarming and can endanger living beings. These are causing an irrevocable change. According to repeated studies and reports around the world it has been concluded that:

- Degradation in Air Quality costs the global economy $5 trillion annually. [1]
- 1 in 8 deaths around the world linked to air pollution. [2]
- 92% of world population lives with dangerous air pollution. [2]

Air pollution is both an environmental and a social problem, as it leads to adverse effects on human health, ecosystems and the climate. Air pollution is one of the largest environmental health risks today. Quality of the air is the most important factor that directly influences the incidence of diseases and decreases the quality of life. The use of multiple parameters for air quality monitoring makes it possible to do a detailed level analysis of major pollutants and their sources. These monitoring systems are important in many smart city projects for monitoring air quality and for controlling the main pollutant concentrations. The technology used in this project is a practical implementation of the concept of Internet of Things. This project is an exploration of the possibilities of use of this technology in a rapidly changing world where environmental health is becoming a serious threat. Using Arduino, data is collected and sent to database and required work is implemented on the data gathered. A few sensors are also used such as temperature and humidity sensors and a few gas sensors to monitor changes. In this IOT project, we can monitor the change in pollution level from anywhere using your computer or mobile. We can install this system anywhere and it can also provide a notification when air quality goes beyond some level.

The pollution in the country is increasing rapidly. Under these circumstances it is crucial for each and every one to be able to monitor the situation of Air Pollution and Air Quality around us. Asian cities have some of the worst Air Qualities around the world, with the concentrations of poisonous and flammable gases having consistently high concentrations. In India the situation is becoming worse by the day. Our capital has been worst hit by Air Pollution, with 2016 winter recording some of the highest numbers ever. [8]

Current air pollution networks consist of few stations instrumented with costly air quality monitoring systems, which provide accurate data but only in few static locations, and which are further complemented with dispersion models. [3]

The latest in the field of communication technology is the Internet of Things (IOT). By using IOT one can wirelessly automate and communicate with different machines and devices over the Internet. This form of communication can use Bluetooth, LAN or WLAN for communication. [7]

Thus, a practical realization of the monitoring of the environment using Internet of Things via Wi-Fi is what has been attempted here. In the light of the current rates of industrialization and unhealthy pollution levels, monitoring the air quality is immensely necessary to ensure preventive measures and better quality of living.

Here a portable model is presented that will incorporate a node MCU having a Wi-Fi module and a few environment sensors to monitor gas levels. The idea behind this work is to meet the upcoming challenges of the modern practical applications of wireless communication and to facilitate our successors with such splendid ideas that should clear the concept about wireless communication and control system.

There are many real life situations that remote monitoring. There will be some conditions where a wired connection between a remote appliance/device and the control unit might not be feasible due to structural problems. In such cases a wireless implementation is a better choice.

A. Aim and Objective

The main objective of IOT Air Monitoring System is that the Air pollution is a growing issue these days. It is necessary to check air quality and keep it under control for a better quality and healthy living for all. Here we propose an air quality monitoring system that allows us to monitor, check and control live air quality through IOT. System uses gas sensors to sense presence of harmful gases in the air and constantly transmit this data. The sensors interact with Arduino which processes this data and transmits it over to the website. This allows the officials to monitor air pollution in different areas and act against it. And if system detects hazardous air quality it alerts authorities so they can take measures to control the issues. Further the data collected from the sensors helps us to predict the air quality using ml algorithm such as linear regression. Further if you want to search any data from previous records you can do so as well as it will show analysis based on the data collected in pictorial form.

II. LITERATURE SURVEY

Duk-Dong Lee and Dae-Sik Lee (2001) state that natural atmospheric environment has become polluted and is rapidly deteriorating due to the dramatic growth in industrial development and urbanization. Thus, monitoring and control of such pollutants is imperative for prevention of environmental disasters. Use of conventional analytical instruments for monitoring purpose is time consuming, expensive and seldom used in real-time in the field. An effective alternative is use of solid state gas sensors that are compact, robust with versatile applications and low cost. They have also presented comparison between analytical instruments and briefed about the various solid state gas sensors namely semiconducting type, capacitor type and electrolyte types sensors. [10]

Pummakarnchana et al (2005) are of the opinion that economic growth and industrialization are proceeding at a rapid pace, accompanied by increasing emissions of air polluting sources. They emphasize on the urgent need for suitable monitoring systems to ensure rapid detection of air pollution levels and for reliable quantification of polluting sources in order to prevent further deterioration in polluting levels. [11]

Jung, Y. J., Lee, Y. K., Lee, D. G., Ryu, K. H., and Nittel, Sare the opinion that the common meters available in the market are Fluke CO-220 carbon monoxide meter for CO, Amprobe CO2 meter for CO2, ForbixSemicon LPG gas leakage sensor alarm for LPG leakage detection. The scientists or researchers in this field have proposed various air quality monitoring systems based on WSN, GSM and GIS. Now each technology has basic use according to the intended function, as Zig-bee is meant for users with Zig-bee trans-receiver, Bluetooth. [12]

A new generation of air quality monitors is now being developed to provide localized, easily accessible and real-time air quality readings - but the potential benefit is only just starting to be realised. It is generally regarded that whilst measurements from air quality reference stations are highly accurate, they are not sufficiently location-specific. Key pollutants – such as NO2 and PM2.5 – vary dramatically over distances and time intervals, but the large size, maintenance requirements and relatively high cost of reference equipment limits the use and places it can be installed. [5]

In our project Air Quality Monitoring System, monitoring the air quality will become much simpler. This will help us have a fair idea about the repercussions of the harmful gases in air. Using gas sensors the harmful gases can be detected and if the gas emission goes beyond a certain level the responsible authorities will be informed about it so that they will take the needed actions.

III. DESIGN AND IMPLEMENTATION

A. Selection of Component

The components used for the design have been chosen after mindful consideration and study. Components are chosen for carrying out the work by keeping the following reasons in mind [4]:

1) Arduino: The Arduino UNO R3 board was used to realize this project because, using an Arduino simplifies the amount of hardware and software development one needs to do in order to get such a system running. The Arduino microcontroller platform already has the power source and reset circuitry setup as well as circuitry to program and communicate with the

microcontroller devices over USB. On the software side, Arduino IDE provides a number of libraries to make programming the microcontroller easier. The greatest advantage is having the hardware and software platform set up already, especially the fact that it allows programming and serial communication over USB. Hence it is convenient to code using its inbuilt libraries according to what we require to do. Also, once loaded the USB can be disconnected and the Arduino will be updated with the latest code compiled.

2) Sensors: For gas detection and environment monitoring, sensors are used which checks two basic conditions, one is the temperature and humidity monitoring and other is the gas level 381 detection for warnings. DHT11 is appropriate to monitor the ambient temperature and humidity, and MQ2, MQ7, MQ135 gas sensors detect smoke, CO, NH3 gas smoke AQI levels respectively.

Sensors Used-

DHT11: The DHT11 Temperature and Humidity Sensor has a calibrated digital signal output with the temperature and humidity sensor complex. It has good quality, quick response, anti-interference ability and performance advantages. Compact, low power, signal transmission distance up to 20 meters, making it a variety of applications and even the most demanding applications.

MQ7: The MQ-7 is a Carbon Monoxide (CO) sensor suitable for sensing CO concentrations in the air. It can sense CO-gas concentrations anywhere from 20 to 2000 ppm. It makes detection by method of cycle high and low temperature, and detect CO at low temperature. It is mostly used in domestic CO gas leakage alarm, industrial CO gas alarm and portable CO gas detector.

MQ2: The MQ-2 is a flammable gas and smoke sensor detects the concentrations of combustible gas in the air and outputs its reading as Analog voltage. The sensor can measure concentrations of flammable gas in the range of 300 to 10,000 ppm. The MQ-2 gas sensor is sensitive to various gases such as LPG, i-butane, propane, methane, alcohol, Hydrogen and smoke. They are used in gas leakage detecting equipment in family and industry and in portable gas detector.

MQ135: Q135 alcohol sensor is a Sno2 with a lower conductivity of clean air. When the target explosive gas exists, then the sensor's conductivity increases as the gas concentration level rises. By using electronic circuits, it converts the charge of conductivity to correspond output signal of gas concentration. The MQ135 gas sensor has high sensitivity in ammonia, sulphide, benzene steam, smoke and in other harm full gas.

3)Alert: When the gas levels go beyond the mentioned levels that are injurious to health, the people in its immediate vicinity are notified instantly.

4)Wireless transmission: The wireless mode of transmission was adopted using node MCU. Though there are many methods of wireless communication but node MCU was selected for this device because compared to other techniques, this requires an active Internet connection so it can be implement anywhere and it can effectively transmit data nearby. Node MCU is an open source IOT platform. [4] It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. [6]

5)Data: The data gathered would be transferred to a smart monitor, such as a computer screen where a webpage would be displaying the readings or smart phone application, for real time monitoring of environment.

B. Methodology

The above mentioned parts are connected as per the circuit diagram in Fig. 1. And Arduino and node MCU are connected as per fig 2 and DHT11 sensor is given power by node MCU and its data is transmitted to Arduino. Before making the connections, the gas sensors had to be kept on for 24 hours for calibration. [9]

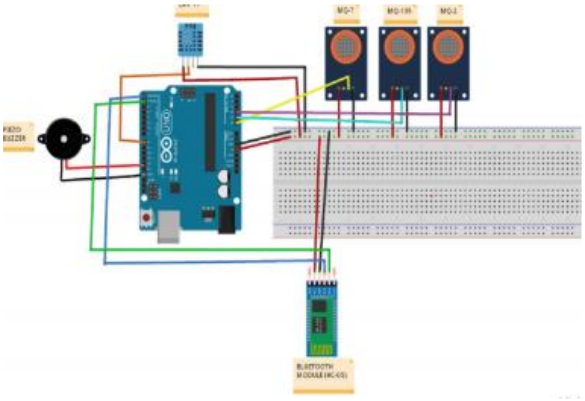

Fig. 1. Circuit Connection of the components

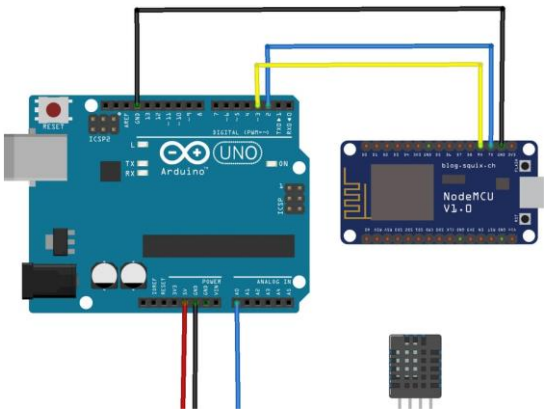

Fig. 2. Circuit Connection of Arduino and node MCU

C. Implementation

The implementation starts by mounting the four sensors namely MQ2, MQ7, MQ135 and DHT11 on the bread board. After being mounted their pins are connected to the Arduino. If Arduino falls short of providing the VCC to any of the sensors then they can receive the same from the node MCU. Now, this node MCU has integrated esp8266 Wi-Fi module within itself and also it is compatible with the Arduino so it is rare that we find any error. The sensors once connected with Arduino and node MCU we write the code for transmitting data from the sensors to the Arduino in the Arduino IDE as Shown in fig 3. Once this code is compiled the sensors will start sensing the environment's air and give readings. The data collected in the Arduino is send to node MCU Now these readings must be received and for that purpose we make use of node MCU which makes it possible to receive and display the data received from the sensors on the monitor. This data is temporary because we haven't made any provision for storing this data. Therefore, we have used a cloud storage which stores this data received from the sensors respectively for each one. Each time the sensor gives a reading it is uploaded into the database. This is implemented with the help of Node MCU. Node help us to transfer data easily due to its inbuilt Wi-Fi module. We have created a webpage which in the first look itself keeps us updated with the air quality around our vicinity. We have also made it possible to see the reading of our four sensors separately. Graphical representation of the air quality also will be shown on the main page. People are able to see any data for each sensor by accessing the search button. Until now we have gathered data from the sensors and updated them in our database. If the Air Quality becomes hazardous, we will notify the subscribers via Email. This data is now supposed to be analysed. This is done by using linear regression algorithm which we will be using for prediction. Also based on the data received Analysis is done using Graphical representation to show the fluctuations in the data.

Algorithm: Steps-

1. *All four sensors DHT 11, MQ135, MQ7, MQ2 are connected to Arduino.*
2. *Arduino is connected to node MCU for serial communication using pin no 5 and 6.*
3. *Read data from sensor in Arduino.*
4. *Convert data into json format using arduino json library.*
5. *Json data is sending to node mcu via serial communication.*
6. *All data displayed over serial monitor of nodemcu.*
7. *Creating hotspot and connecting to Wi-Fi of node MCU using ssid and password.*
8. *Using http port 80 data is sent to database.*
9. *Read data after a delay of approximate 20 seconds.*

```
Connecting to deepak

WiFi connected
IP address: 192.168.43.13
Netmask: 255.255.255.0
Gateway: 192.168.43.1
JSON received and parsed
{
  "MQ2": 90,
  "MQ7": 491,
  "MQ135": 163,
  "h": 59,
  "t": 30
}
MQ2 90
MQ7 491
MQ135 163
Temp 30
Humid 59
--------------------xxxxx--------------------
connecting to drc186010.000webhostapp.com
Requesting URL: /aqms/write_data.php?temp=30&hum=59&co=491&smoke=90&aqi=163
```

Fig. 3. Readings as received from Arduino into node MCU and displayed into the serial monitor of Node MCU

D. GUI

The user interface that we have created for Air Quality Monitoring System is basically a website which can be accessed from any location and get the latest updates about the air quality. At a glance it shows the temperature, humidity, AQI level, smoke level, CO level and a graphical representation of air quality. It also has information about what the information in the website is all about in the About Us section. If the user has any issues regarding the website he/she can inform us through the Contact Us section. The sensors connected to the Arduino send the data collected from them to the database over the node MCU which has an integrated Wi-fi module in it. There are four sensors namely MQ2, MQ7, MQ135, DHT11 and the database for each of them is created separately. There is a section in the website called Sensors in which we have segregated the data collected from each sensor so there is a provision to select which sensor's data the user wants to access. The database for each sensor contains the date and time when the reading was recorded and updated. It gives the readings of the sensors in ppm. If the air quality goes beyond a certain critical level the authorities will be notified accordingly. The user can also search the specific day's data by entering the date in the search area provided in the database. Linear regression algorithm will be used for prediction purposes. The users can Subscribe to the system and if the Air Quality becomes Hazardous the user will be notified using email. The user can also predict the data using the predict button provided in the GUI.

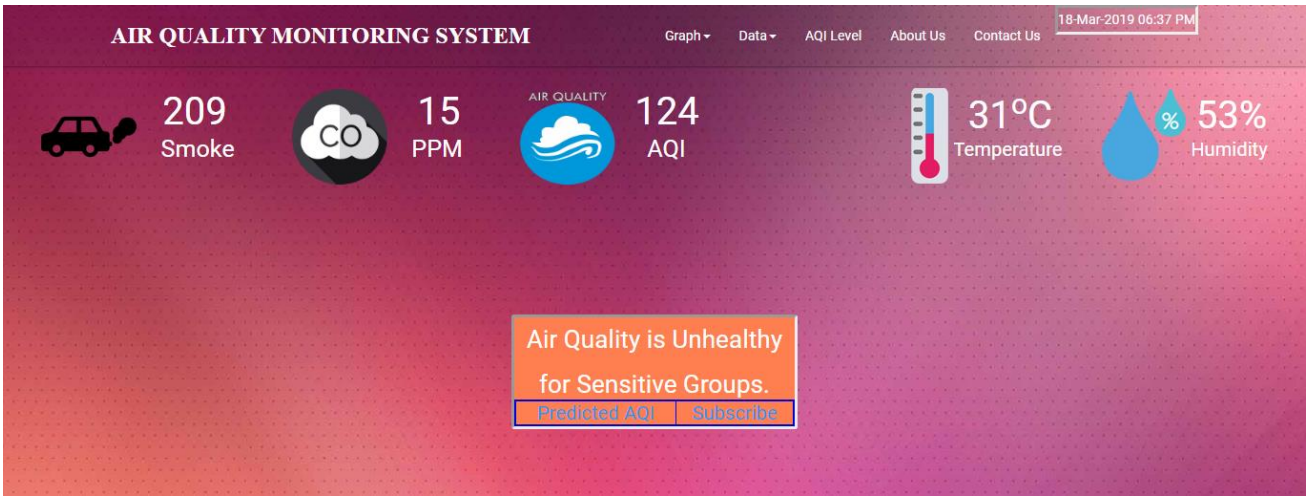

Fig. 4. GUI of Air Quality Monitoring System

This is the homepage of the system GUI. It displays the values in ppm for smoke and CO sensors and AQI. Thetemperature is given in degree Celsius and humidity in percentage. These values keep on updating as and when the data is obtained from the sensors and added in the database. This website can be accessed from anywhere and therefore is handy.

IV. Result And Discussion

The implemented circuit diagram is shown in Figure 5

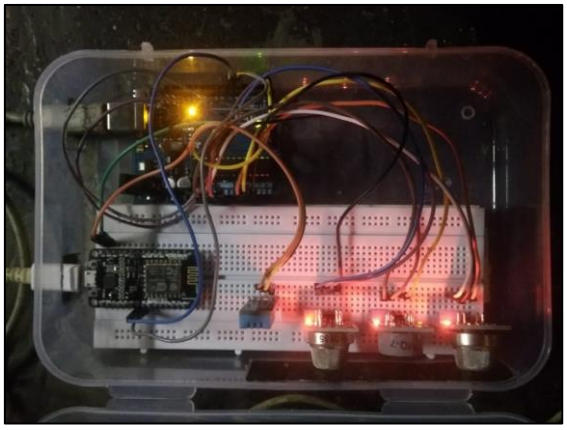

Fig. 5. All the equipments are attached inside the box along

with the connections making it portable and the power supply is given by the power bank.

A. Readings

The results are obtained on the serial monitor using the serial monitor app. Their values are shown as in figure 3

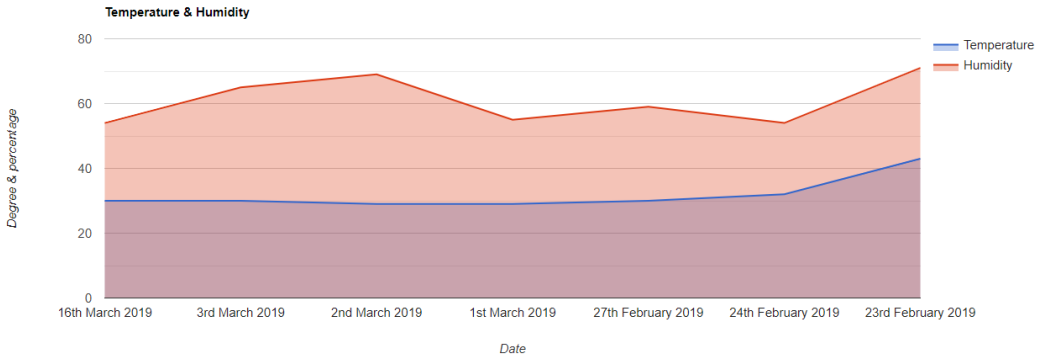

Fig. 6. Graph representing fluctuations of temperature and humidity collected across the week

Graph representing fluctuations of temperature and humidity collected across the week. The red line shows the humidity and blue line shows the temperature. The x-axis gives date and the y-axis gives the degree and percentage for temperature and humidity respectively. This graphical representation is in the form of a line graph.

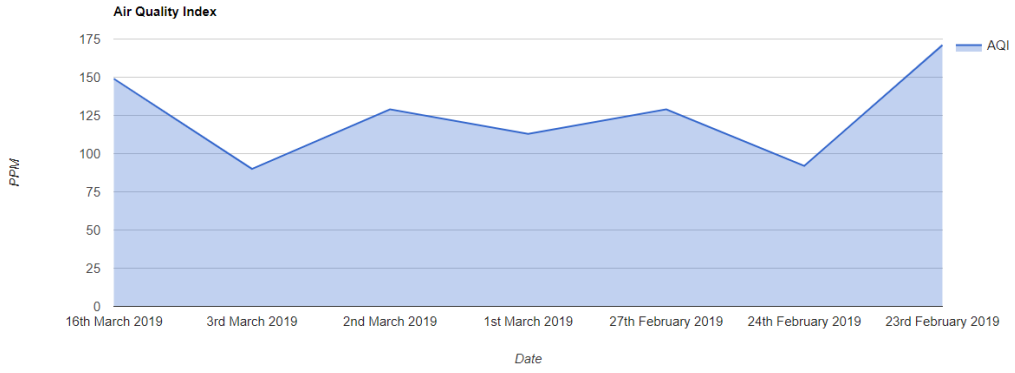

Fig. 7. Graph representing fluctuations of Air Quality Index collected across the week

The x-axis gives date and the y-axis gives the air quality in ppm (parts per million). This representation is in the form of a line graph. These values will determine whether the air quality is healthy, moderate or hazardous and so on as per the predefined ranges for AQI.

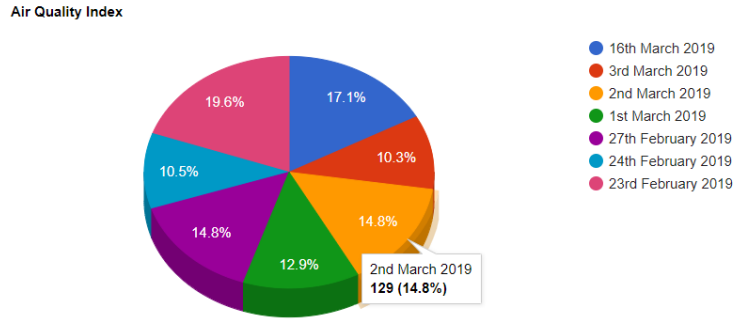

Fig. 8. Pie chart representing fluctuations of AQI level collected across the week.

Since the AQI is measured in ppm and data in a pie chart is represented in the form of percentage, the average of values is being taken for each day and the values across the week is displayed in percentage form. But if u take the cursor near those values you can find the value in ppm as well.

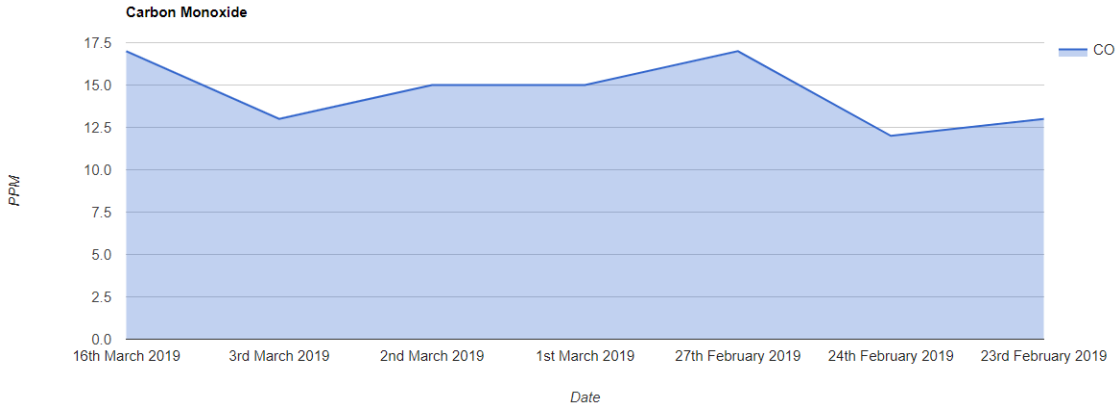

Fig. 9. Graph representing fluctuations of Carbon Monoxide collected across the week

The x-axis gives date and the y-axis gives the concentration of carbon monoxide gas in the air in ppm (parts per million). This representation is in the form of a line graph.

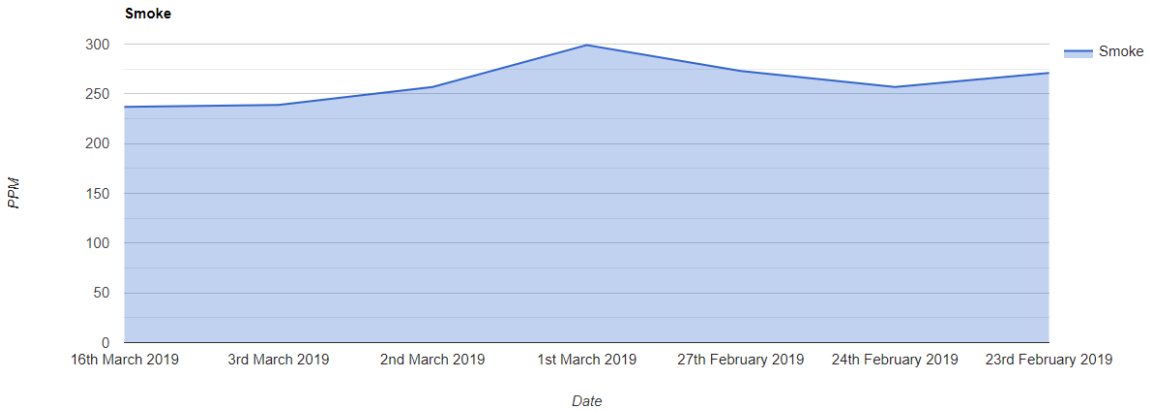

Fig. 10. Graph representing fluctuations of Smoke collected across the week

The x-axis gives date and the y-axis gives the concentration of smoke in the air in ppm (parts per million). This representation is in the form of a line graph.

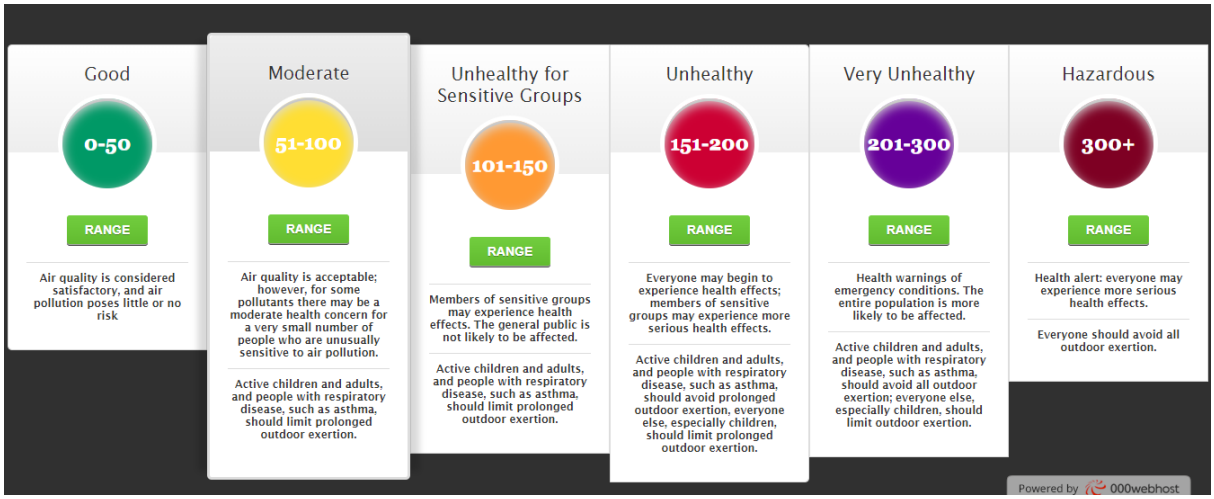

Fig. 11. Predefined AQI level

Predefined AQI level. AQI level is determined if its value lies in a particular predefined range. If AQI level is 82 ppm as shown in Fig.5. then a message will be displayed saying that the 'Air quality is moderate' on the homepage. This is because 82 lies in the range 51-100. Similarly it will be displayed for other values as well.

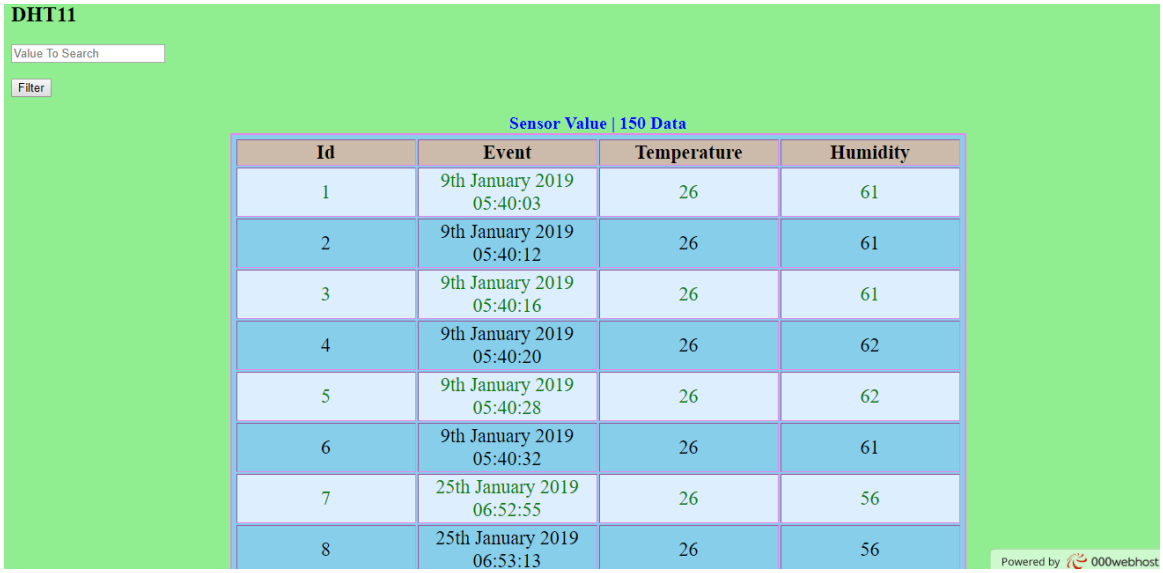

Fig. 12. Database for Temperature and Humidity

Here Database for Temperature and Humidity, we can search for any month's data up-to the current date by entering the name of the month in the area provided as 'Value to search'. You can also enter any value in form of a number and if that reading is present in the database then it will be reflected and shown to the user. This can be done in the tables of the remaining sensors as well.

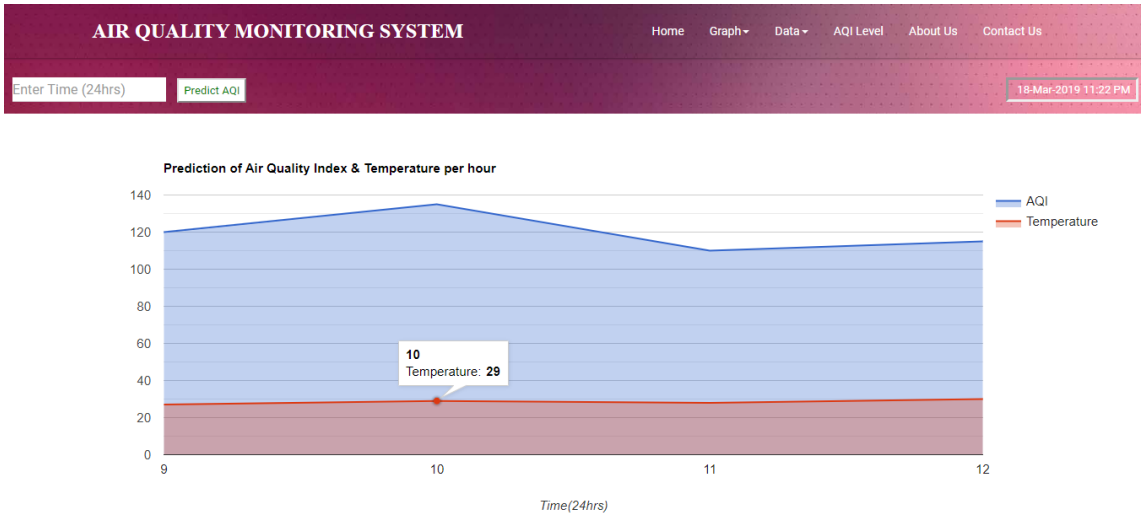

Fig. 13. Graphical representation of AQI and temperature.

Displaying per hour prediction of AQI data and temperature of the same day. The x-axis gives the time in a 24-hour format which means we are considering the current day and the y-axis denotes the values in ppm. The user can also directly enter the time to predict values of same day in 24-hour format.

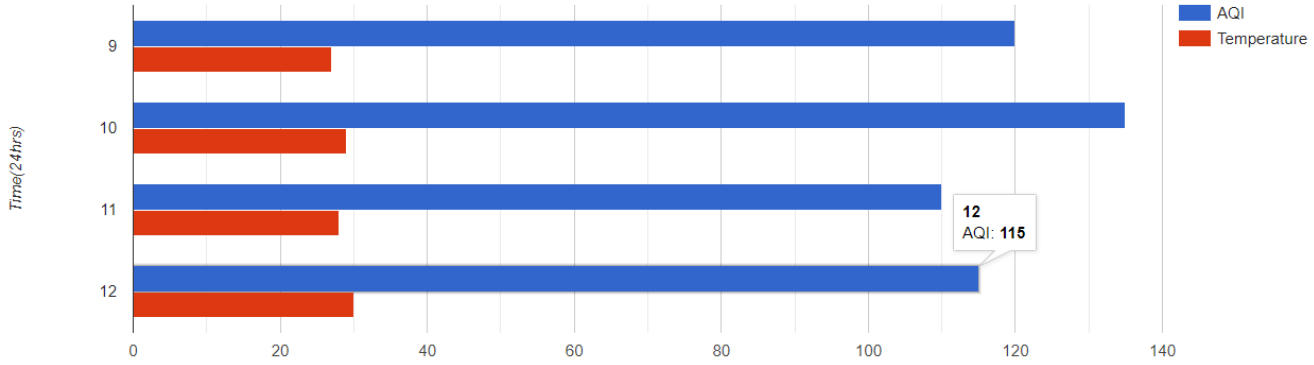

Fig. 14. Predicted graphical representation of AQI and temperature.

For instance if the user enters the time 9, 10, 11, 12 one after the other in 24 hour format, then the predicted values will be displayed in the form of a bar graph where the orange bar shows the predicted temperature and the blue bar shows the predicted AQI.

B. Observations

A comparison can be made based on the above obtained results. We can see that even though the ambient temperature and humidity are higher in a closed room environment, the environmental pollution in such a place is lower than outside. Hence, this device can be placed in different environments to obtain air quality results in a similar fashion. Moreover, the readings will be stored in the database so that we can predict the air quality in the nearby future by taking average of the readings stored.

V. CONCLUSION

In the last decade, a specific demand for air quality monitoring in order to protect the environment has risen. The knowledge on air pollution concentration in real time is necessary for taking appropriate action to prevent and mitigate the problems due to air pollution. Conventional air quality monitoring approaches have limitations with respect to time, area coverage and expenses involved in the establishment of air sampling and laboratory equipments. Consequently, the data available on air pollutants and their concentration levels are inadequate. In this project we have done an analysis on the data that we have collected from the sensors used. We can predict the air quality of the next day and also notify the concerned authorities if the air quality goes beyond a certain level which can be hazardous.

Limitations and Future Scope:

Although here a fine grained approach of air quality data collection has been suggested as opposed to the conventional course grained approach [6], a major limitation of this device is that using Bluetooth, at a time only one display device can connect with this device and receive the values. There is a scope for overcoming this limitation by using a Wi-Fi module (ESP8266) so that simultaneously more than one devices can connect with this device. But again, this will decrease the portability of the system since an internet connection is necessary for Wi-Fi communication. An Arduino board contains 6 analog pins out of which we have used only 3 to connect our sensors. There are 3 more pins available where we can add 3 more sensors such as:

- MG-811 (Carbon Di-oxide)
- ME3-O2 (Ozone)
- MQ-214 (Methane)

This will increase the efficiency of this device.

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