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Research Paper

Design and development of air quality management devices with sensors and web of things

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Abstract

With the rapid increase in urbanization, there is a huge and urgent need of controlling the air quality so that we can breathe freely. We need oxygen to live and sustain life and for that controlling the environment is must otherwise it would create a great damage. According to a survey, pollution is claiming one life every 23 seconds in India and the figure can go to an extent of 1 billion people dying due to air pollution by 2030. If there would be something free on earth then it would be just Carbon. The earliest step we can take towards this cause is the detection pollutants present in the atmosphere after which the action can be taken against these pollutants. The detection can be done by the use of various sensors like MQ-2, MQ-135, DHT-11, PM10/PM2.5, AQM65 etc. and then obtaining the real-time data to the local servers by the means of IoT. The pollutants can be easily monitored when connected through the internet and local servers. The sensors will work upon a micro-controller which is used to store the data and transmission of data to the servers. Afterwards, the data can be easily accessible on the application developed.

Keywords: *Air pollution; Carbon emission; IoT servers; Sensors; Urbanization*

1. Introduction

Imagine the earth with people relying on masks for their survival in order to inhale the fresh air, and where the oxygen is being supplied to their homes and offices just like electricity. Sounds weird, but the ugliest truth for the future generation relies on us as how far we can be successful in minimizing the air pollution. Taking Delhi into account, we recognize that Delhi has the highest pollution level amongst all the major cities of India. It has highest concentration of $PM_{2.5}$ particles amongst 1600 cities globally. These particles are so tiny that when inhaled can directly lodge in lungs. According to a survey, in year 2013, Delhi's $PM_{2.5}$ average was 153 mg/cubic meter which indicates much bigger amount of pollutants present there. On earth, there is a huge demand of business and pleasure and in due of this, there is a large increase in the production of industries which is directly affecting the environment and increasing the concentration of unwanted harmful gases like Carbon mono oxide and carbon dioxide etc. resulting in the most popular phenomenon i.e. global warming. It's a scary truth that the depletion of oxygen content in air was threatened since when the first industry was setup on earth and since then every day is turning out to be a huge challenge for the mankind for their survival. Selfishness of human is leading to the destruction of earth.

With the increase in the urban population and traffic density, the air pollution has been drastically increased affecting the surrounding environment and human health. Most of the air pollution is being caused by vehicular emissions. However on the other hand, the mega cities of the developed countries are trying their hand on improvement on account of efficient implementation of urban air quality management [1]. So in order to extract the harmful gases from atmosphere, firstly we have to detect the pollutants present in the air. Since most of the urban as well as rural air pollution system uses smart sensor networks and wireless systems which can measure CO, NO_2, SO_2 [2]. Although the Environmental Protection Agency adopted the new policies regarding the air pollutants in 1997 imposing regulatory limits on fine particles measuring less than 2.5 µm in diameter ($PM_{2.5}$) but at later stage this decision was upheld by the US supreme court [3]. In the current generation, the air quality is being recorded by utilizing pathway of static measurement stations which is further being managed by official authorities. These type of stations are reliable up to great extent and are able to measure an extensive range of air pollutants by deploying modern analytical instruments. But due to its huge cost estimations in gathering and operating these stations results in limiting the spatial resolution of the published pollution control maps which makes it unfavorable sometimes for the system and therefore some other tactics is being progressed and currently in use [4].

The device we are constructing for the detection of air pollutants consists of a software installed on a micro controller board using IoT. The micro controller board consists of sensors attached with it. **MQ-2, MQ-135, DHT-11 PM10/PM2.5, AQM65, MiCS-OZ-47** are some of the components (sensors) of the device. The different sensors detect their specified properties and generate a data which is thus stored by the micro controller. The stored data is then transmitted to the local IoT servers with the help of Wi-Fi or GSM modules and afterwards it is made available to the local bodies through any means of open source.

IoT can be fundamentally used in all the environmental situations. The IoT is a recent communication paradigm that focuses on or entitles a near future where most of the objects would be comprising of microcontrollers, transceivers for their communication digitally [16]. Immobile objects and also the objects in motion both, are the sources of some different chemical pollutants in the atmosphere which include Suspended particulate matter i.e. SPM, Carbon Monoxide i.e. CO, some oxides of Nitrogen like NOx, few oxides of Sulfur like SOx, etc. Since we cannot neglect the fact that due to presence of some of these types of chemical pollutants in the atmosphere, there is an increase in the occurrence of some diseases like Cancer, Asthma, pneumonia, and some chronic diseases [5].The concentrations of different pollutants are usually taken at different sites since there exists a special case under which the concentrations vary from its original value in a certain local area [6]. The monitoring of air quality parameters is quickly taking place because of its researches in the improvement of small size, lower cost air pollution sensors which gives the information in the real time, huge knowledge in the smart generation computing knowledge, and also its remote access.It is believed that these advances in technologies can actually modify the old traditional air quality observations by its consistent and proper observation. Nowadays, these technologies which include sensors have started giving people and groups the requirements to alter their ecological exposures and with these advancement, strategies can be implemented in order to decrease the pollution as well as health issues [7].

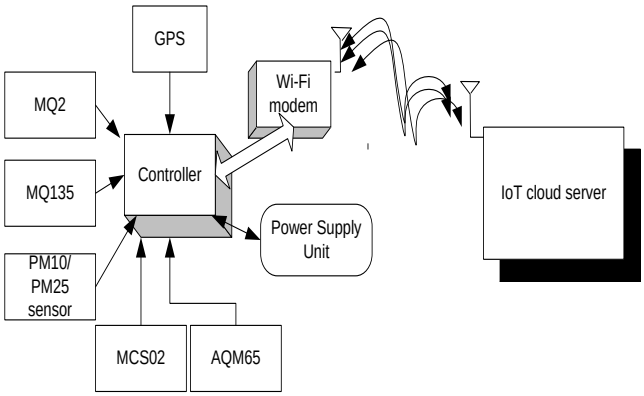
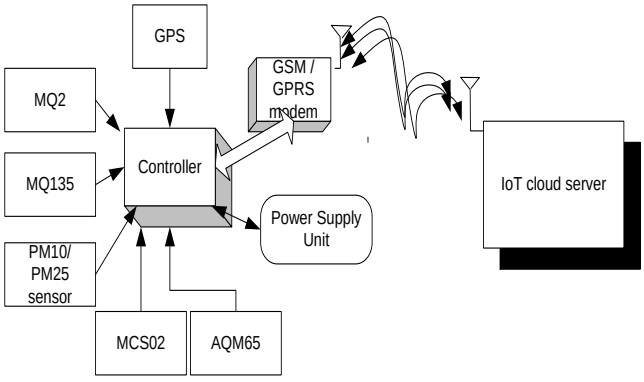


Fig. 1(a): Represent single node architecture using Wi-Fi modem.



.**Fig. 1(b):** Represent single node architecture using GSM/GPRS modem.

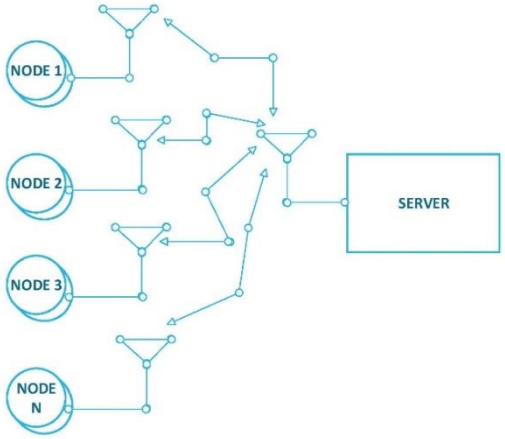


Fig. 2: Represent generalized diagram.

2. Brief description of the block diagram

The device consists of sensors such as MQ-2, MQ-135, DHT-11, PM10/PM2.5, AQM65, MiCS-OZ-47 attached to the micro controller, here the block diagram represents the functioning of the device in the form of blocks which indicates all the physical quantities provided and their interconnection with the micro controller [8]. The Internet-of-Things (IoT) is the formation of network of physical devices to connect and share data [9]. In these two block diagrams, fig1 (a) and fig1 (b) shows the creation of setup of device, attachment of all the sensors with micro controller which will help us in detection of air pollutants by obtaining the data and thus we can apply different methods to reduce the pollutants. The micro controller is attached to a Wi-Fi which transfer the data to the local server as shown in fig.2. The stored data will be made available to the local bodies with the help of an application. The design included following major hardware components:

2.1 Micro controller (Arduino): It is a multiuse programmable hardware platform containing a blue circuit board on which the programming is done. This micro controller does not require any programming skill or any kind of electronics theory knowledge as it is easy to operate and we can carry it anywhere [10]. The microcontrollers are embedded in the household appliances, phones or any automobiles. It also gives required input voltage to sensors for their operation and stores the data collected from the sensors.

2.2 GPS: GPS sensors are used to locate the device by giving its precise location and also the velocity of object, thus the signals are obtained by the receivers which calculates the data and resend the information back to earth.

2.3 MQ-2GAS sensors: This is a semiconductor gas sensor mainly used for the detection of gases such as CO. It is also used in fire and gas detection alarm, leaking of gases from industries, houses etc. The gas sensor has high sensitivity, fast response, wide range of detection and many other useful things which are required the detection of gas pollutants [10].

2.4 MQ-135 GAS sensors: This is also a semiconductor gas sensor used for the detection of the gases like NH_3, NOx, Benzene, alcohol, smoke, CO_2 etc. The sensor has a wide detecting scope, stability and long life, fast response and high sensitivity, and it has simple drive circuit which prove to be useful in the detection of air pollutants [11].

2.5 PM10/PM2.5 sensors: Generally PM or particulate matter is a term used for the mixture of solid particles and droplets of liquid. It is used for examining the particulate matter present in the atmosphere at different sites or locations and conditions [12].

2.6 AQM 65: These are the sensors generally used for the detection of the gases like CO and HC's and oxidizing gases such as NO_2 and O_3. The sensor also allows the detection of gasoline pollution and diesel pollution emitting from automobiles. It has high sensitivity, wide detecting range and also the fast response features which is needful [13].

2.7 MiCS-OZ-47: The sensor is useful for us in the detection of ozone concentration present in the atmosphere. It also gives the data about temperature and humidity having a dual sensor [14]. The PCB based module for ozone sensing can be configured to deliver the ozone readings in PWM output or binary output.

2.8 DHT-11: The sensor is used for the measurement of temperature and humidity and has many advantages including fast response action, user friendly interface, and also it is cheaper than most of the air quality sensors [18].

Similarly using all the components stated above, another same design of the device is created but with GSM modem instead of a Wi-Fi modem for receiving and transmission of data from microcontroller to the IoT servers.

Likewise, N no. of nodes are created using the same components and design and afterwards they are placed at different prime locations for detection of the air pollutants and receiving or extracting the data from the sensors transmitting it through Wi-Fi and GSM modem. The data collected from all the devices is thus collected and stored in the main server for interpreting and making the readings available to the local bodies.

3. Result and conclusion

The paper consists of briefing about a device/ setup which is used for the detection of air pollutants present in the atmosphere using various sensors and IoT servers. The model gives a brief idea about the pollutants present in the atmosphere and their quantities and also what can be done in order to decrease the air pollutants. The device facilitates enhanced operational intelligence to be obtained for actionable decision support strategies to be designed. It is as simple as placing the hardware design of the device open in the atmosphere, extracting the data about the air quality parameters and storing the data in readable form and at last making it accessible to the local bodies. The received data is displayed on the device in digital format with the help of microcontroller. The project includes the study about the interaction between surrounding environment and their ill effects and monitoring of air quality no matter how far the device is being placed. The device provides a real- time information about the level of pollution in the atmosphere.

For clearing a picture about the deployment of air quality sensors, few things are to be taken care of like pollution level for some space and time and secondly locating the device to manage the pollution level at that given site and so as to examine that how can we better place the device in order to obtain good quality data and measures [14]. Different concentrations of pollutants are usually monitored at different locations. A careful placing of the nodes is of much importance in order to obtain better results on the pollution maps and for this, a lot of work has been already done in order to tackle this problem [17]. On the other hand, a careful study/analysis on auto-calibration reveals the effectiveness in having an estimation accuracy of the system comprising of sensors in long phase operation [15]. After the detection of the pollutants, further actions can be taken by which it can be made fit for use. As the research about the air pollution is still in progress, we would be able to detect and manage further more pollutants in the atmosphere like oxygen level,greenhouse gases including oxides of sulfur in order to facilitate the complete treatment of the air pollutants in order to live freely and breathe freely. The good air quality would prove to be beneficial for us and surroundings.

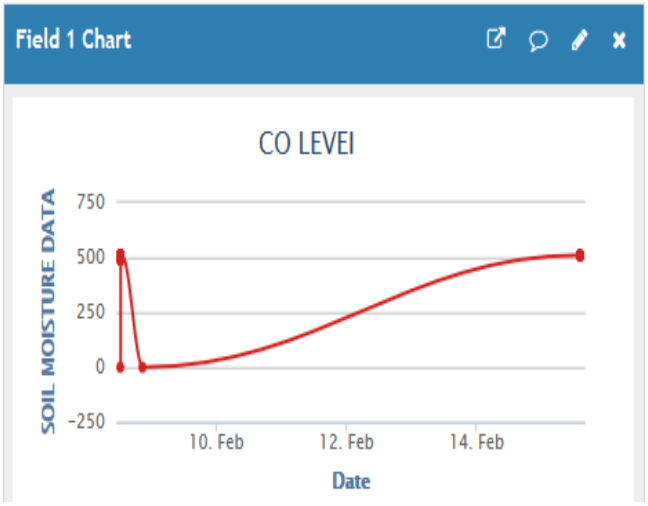


Fig. 3: Snapshot showing the variation in the CO level with time of a particular place in Dehradun region as obtained by the developed device which represents that there is a huge variation in CO level with respect to time.

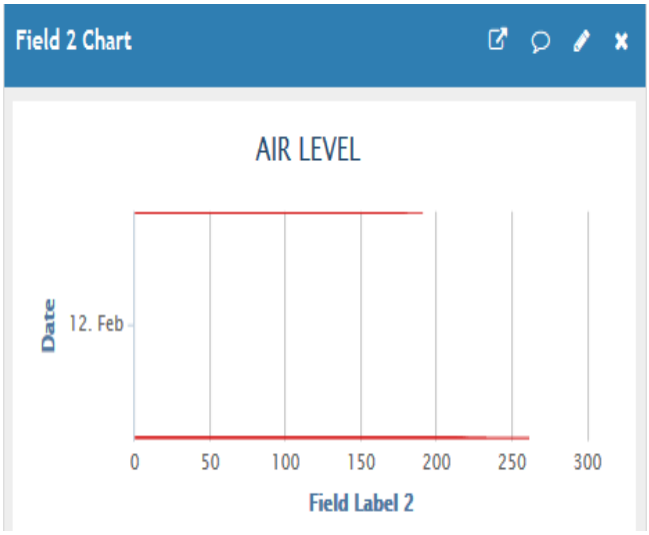


Fig. 4: Snapshot showing the constant variation in Air level with respect to time as obtained by air quality monitoring device.

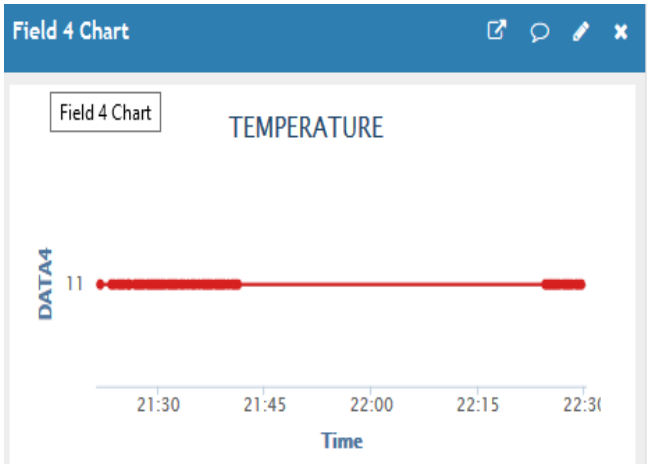


Fig. 5: Snapshot of the data obtained from the developed device showing the constant variation in the temperature with respect to time of a particular place.

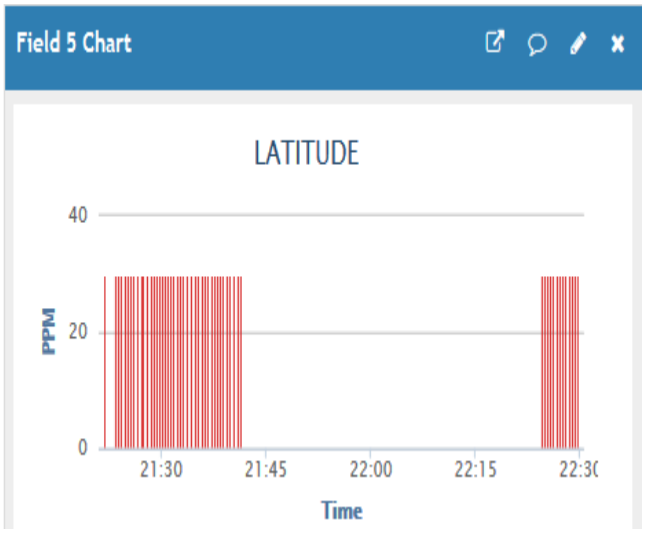


Fig. 6: Snapshot whichdepicts the latitude of a particular place as obtained by developeddevice with respect to time.

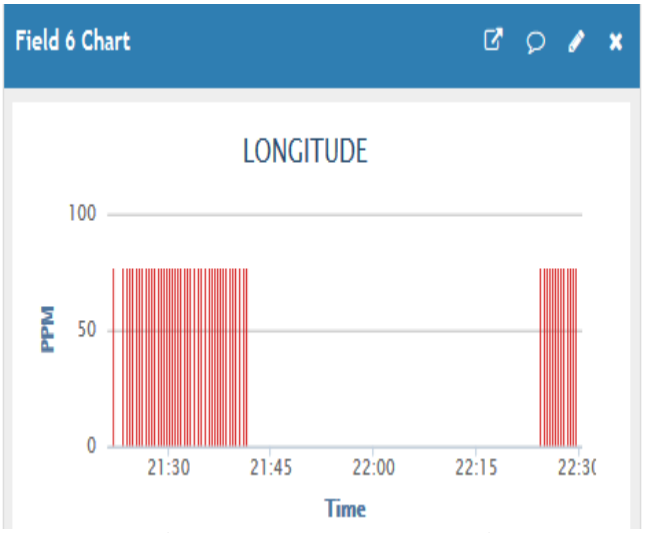


Fig. 7: Snapshot of the device depicting the longitude of a particular place with respect to time.

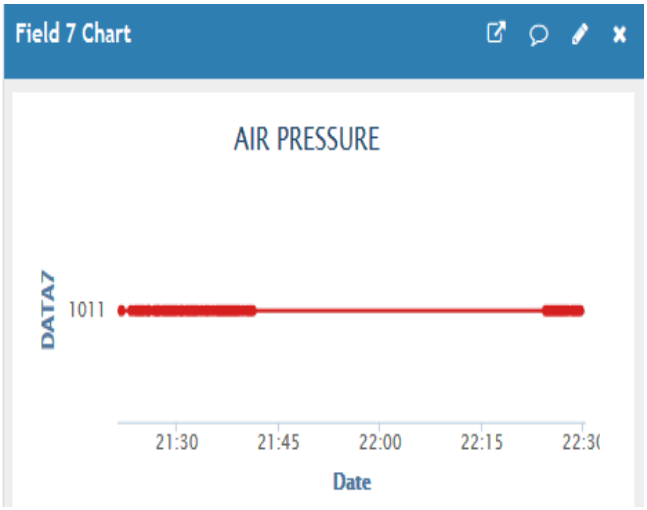


Fig. 8: Snapshot of the data obtained by the device which shows the constant air pressure in the atmosphere with respect to time.

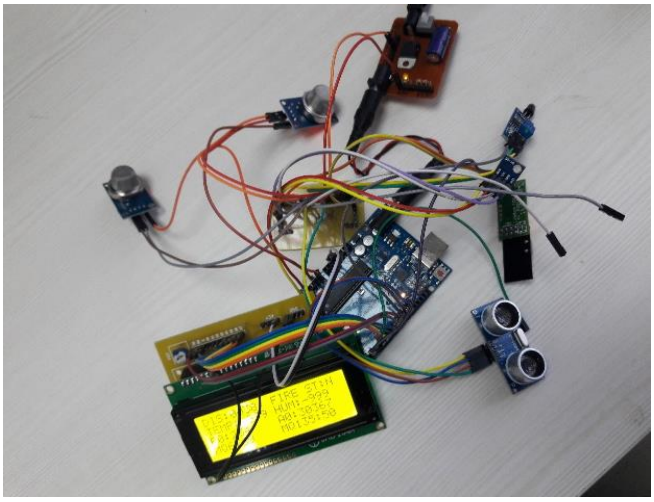


Fig. 9: It represents the developed system consisting of sensors and the data displayed on the microcontroller and related variations in graphs on the monitor.

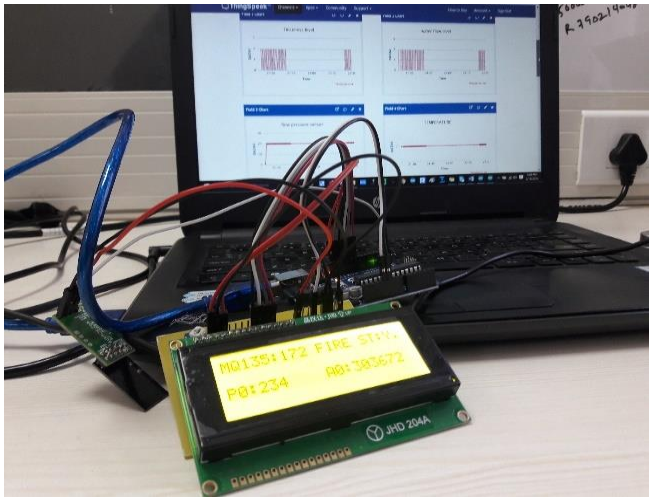


Fig. 10: This picture represents another node created consisting of the same sensors and from which the data is extracted and displayed on the microcontroller from which the data is obtained and displayed on the website or the application developed.

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