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Air Quality Monitoring System For City

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Abstract - *An Objective of this paper is to design and implement a system for air quality monitoring using Internet of Things called as IoT. The model initiates from sensor devices that can sense, compute, and communicate data in a network. This study measures real-time PM2.5, temperature, humidity, Air Quality Index. Monitored data is wireless transmitted via Wi-Fi module to a server. When the sensor node reads pollutant gases composition, temperature and humidity, it will be displayed on the website. The monitored data with date and time can be retrieved as a tabular data for future analysis. With implementation of this work, precautionary alerts can be given to public on the designed website to wear anti-pollution mask, change paths while transporting where there is high air pollution ensuring high reliability. It promotes the public awareness about state of air pollution and how much important it is to reduce it. There will be news, surveys regarding pollution in different countries, different ways to reduce air pollution on the website.*

***Key Words*: IoT , Air Quality Index , Cloud ,Wi-Fi node , Sensor data , smart City.**

1.INTRODUCTION

Air pollution has been common health concern not only for humans but also for animals, plants, oceans, aquatic life worldwide. In most of countries air quality monitoring is done manually via centrally located station. Meanwhile, many populated areas of the world lack Continuous, long term air quality measurement. To date, the Geographic coverage of air quality monitoring networks has been constrained due to the implementation cost, architecture, and individual requirements for monitoring stations.

Internet of Things (IoT) has become a very popular paradigm in the modern wireless communication era.

The basic idea of the IoT is the distribution of all-over "objects" or "things", which collects and exchanges data in order to achieve a common objective by means of mutual interactions. The networked connection of these physical objects to the Internet provides access to monitored remote sensor data, so that it is possible to control the physical world from a distance.

A fundamental aspect of the Internet of Things is the integration with the Cloud infrastructure, which hosts interfaces and web-based applications that enable the communication with sensors and external systems. Therefore, the Cloud computing infrastructure might provide data access and management features, with the aim of collecting and managing data made available by smart objects . A real time monitoring of the existence and the concentration of air pollutants is necessary, in order to check air quality status and trends. By continuous real time monitoring of outdoor pollutant levels, IoT might help health departments to take the most suitable and effective decisions in case the environmental conditions become incompatible with the public health.

In this dissertation work, have implemented a system for monitoring the air pollution based on Arduino and implemented a prototype of this system, deployed it in Dept. of civil Engg. Dept. of Electronics, Dept. of Computer and IT, college hostel, Main entrance, Government College of engineering, Amravati. Moreover have designed a website on Cloud-based platform that manages data collected from sensors and displays it on the website. A comparison between five Cloud computing service models will be performed. Finally will design and investigate the system performance in terms of long-term operability, real-time measurement accuracy compared with nearby stations and feasibility for application in other location.

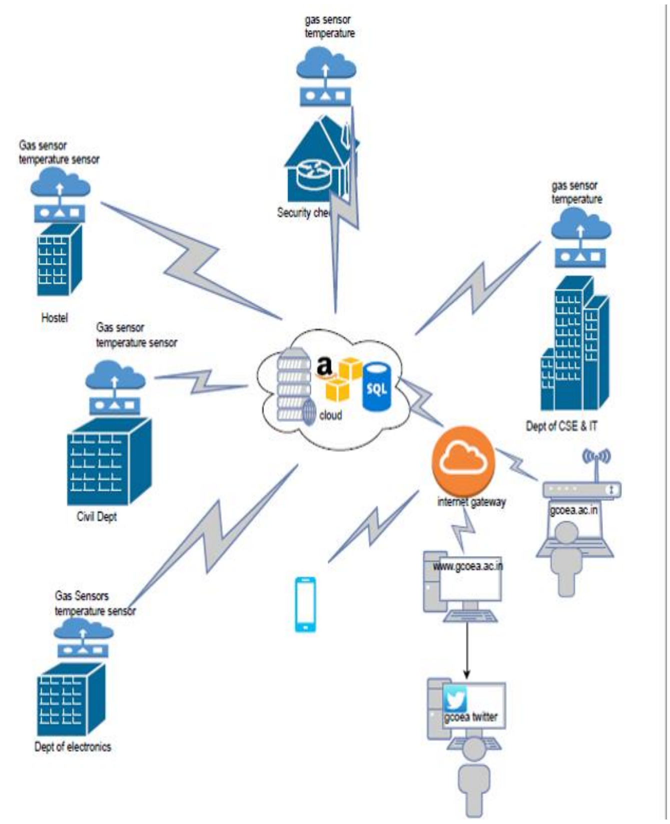
1.1 Literature Review

Some of the existing methodologies for the air pollution monitoring are described as below, In plug and sense device method, it Uses multiple sensors with location co-ordinate, AQI LED indicator is actuated as per pollution level and the Real time pollution level visualized using line graph [2].In distributed sensor data computing, it uses distributed intelligence for the sensor nodes and uses spatial database for locations [3]. In Arduino based method it uses sensor devices for data, Uses ESP8266 Wi-Fi module for connection to server, Uses Node.js and Node RED for displaying data on the server side [4].In personal assessment methods, Biochemical dose assessment methods are used Ex. Biomarkers[5].In ZigBee technology, ZigBee transmitters and receivers are used, GPS module is used for locations for pollution level on map [6].

1.2 Proposed System

The proposed system includes Arduino based temperature, transmitting monitored data to cloud based server. In detail, the following environmental parameters are collected with the aim of measuring air pollution levels: Carbon Monoxide

(CO), Carbon Dioxide (CO_2), Nitrogen Dioxide (NO_2), Methane (CH_4), Hydrogen Sulfide (H_2S), Ammonia (NH_3), Particulate Matter (PM), Moreover, Other parameters like temperature, humidity are measured. In this section, the implementation of the proposed system is discussed.



Arduino is an open source micro-controller which is used with other communication and sensing technologies. This single-board development environment, which allows user to read uploaded data from sensors and allows to control different devices. ESP8266 is a low cost Wi-Fi module with an AT commands library. It allows the Arduino to connect to the Internet through a Wi-Fi connection. Moreover, ESP8266 has a full TCP/IP protocol stack integrated on the chip.

There are some constraints in terms of resolution. Indeed, the inputs uploading from analog sensors operate by default at 10-bit resolution. The on/off switching of the sensors can be operated remotely according to sensor-based data that are stored and maintained directly at the Cloud server. The Arduino collects all the data uploading from sensors and transmits it to the Cloud server by using the Wi-Fi module ESP8266, which is mounted on Arduino through an on-board serial port.

The data on the cloud server displays location wise. The designed website is hosted on the same cloud. Website contains the location wise separate dashboards and news, surveys related to air quality etc. will be updated on the website.

1.3 Sensors

Gas Sensor:
It is often observed that the hazardous gases are present in the air. For its detection the gas sensor used is MQ 135. Air quality sensor MQ 135, is use for detecting a wide range of gases that includes ammonia, aromatic compound, NOx, alcohol, benzene, smoke, CO_2. Sensor is composed by micro AL_2O_3 ceramic tube, Tin Dioxide SnO_2 sensitive layer, measuring electrode and heater are xed into a crust made by plastic and stainless steel net. For work of sensitive components the necessary work conditions are provided by the heater. The enveloped MQ 135 sensor have 6 pin out of which 4 are used to fetch signals and other 2 for providing heating current. MQ 135 has fast response and high sensitivity and wide detecting scope.

Temperature and Humidity sensor:

To distinguish between dry and wet air the temperature and humidity sensor DHT 11 is used. Dry and wet air would be differentiated depending upon the output from the sensor. The DHT 11 is a high-precision digital humidity and temperature sensor which uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and sends out a digital signal on the data pin. These sensor contain a chip inside it that does analog to digital conversion and gives digital signal with the temperature and humidity.

DHT11 uses a simplified single-bus communication. Single bus that only one data line, the system of data exchange, control by a single bus to complete. This sensor will get new data once every 2 seconds. For 0-100% humidity readings it has 2-5% accuracy and for -40 to 80 C temperature readings 0:5 C accuracy.

Simplified single bus communication is used by DHT11 i.e. only one data line. For communication and synchronization microcontroller and DHT11, single bus data for-mat of 40 bit is transmitted, the high rst out. DHT 11 sensor gives calibrated output.

Data Format of 40 bit: 8bit humidity integer data + 8bit humidity decimal data +8 bit temperature integer data + 8bit temperature fractional data+ 8 bit parity bit
Parity bit data definition = 8bit humidity integer data + 8bit humidity decimal data +8 bit temperature integer data + 8bit temperature fractional data" 8bit checksum is equal to the results of the last eight.

1.3 Mathematical model

The MQ-135 gas sensor senses the gases like ammonia nitrogen, oxygen, alcohols, aromatic compounds, sulfide and smoke. Gas sensor gives output in the range of 0-40 ppm but in India, Air quality index is between the range of 0-500. So to convert gas sensor reading to 0-500 AQI the following AQI formula is used.

Sub-index function represents the relationship between pollutant concentration Xi and corresponding subindex I_i .It may take a variety of forms such as linear, non-linear and segmented linear. Typically, the I-X

relationship is represented as follows:

$$I = \alpha X + \beta$$

Where, α =slope of the line,
β = intercept at X=0.
The general equation for the sub-index (I_i) for a given pollutant concentration (Cp); as based on linear segmented principle is calculated as:

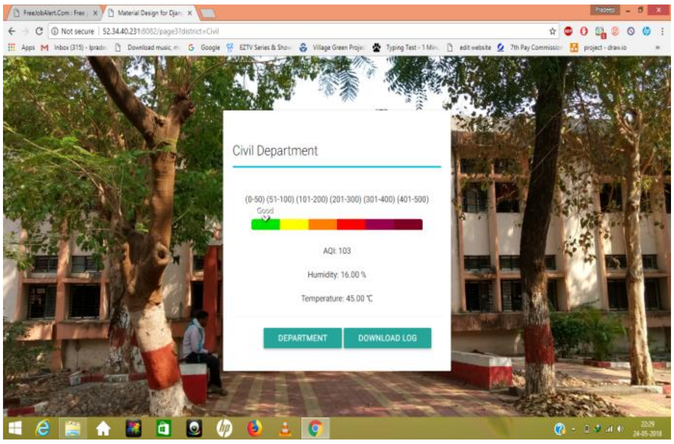
$$Ii = [\{(I_{HI} - I_{LO})/(B_{HI} - B_{LO})\} * (Cp - B_{LO})] + I_{LO}$$

where,
B_{HI}= Breakpoint concentration greater or equal to given concentration.
B_{LO}= Breakpoint concentration smaller or equal to given concentration.
I_{HI} =AQI value corresponding to BHI
I_{LO} = AQI value corresponding to BLO
Ip = Pollutant concentration

2. Performance Analysis

Initially from homepage person needs to choose the specific department of GCOEA, then after choosing the specific department the page will show the real time air quality data of department in each department of the GCOEA campus. The webpage displays the real time air quality status. This saves time and is useful for pollution awareness among people. Use of Internet of Things Technology allows connecting large number of devices to the internet and allows the facility of having access to data anytime and anywhere with the proper internet access.

In the month of April operation from April 15, 2018 to April 29, 2018, the modules successfully collected 360 hours of Temperature, Humidity, AQI data, respectively. The system performed with highest overall data completeness during the summer.



Picture-1: Webpage displaying the AQI

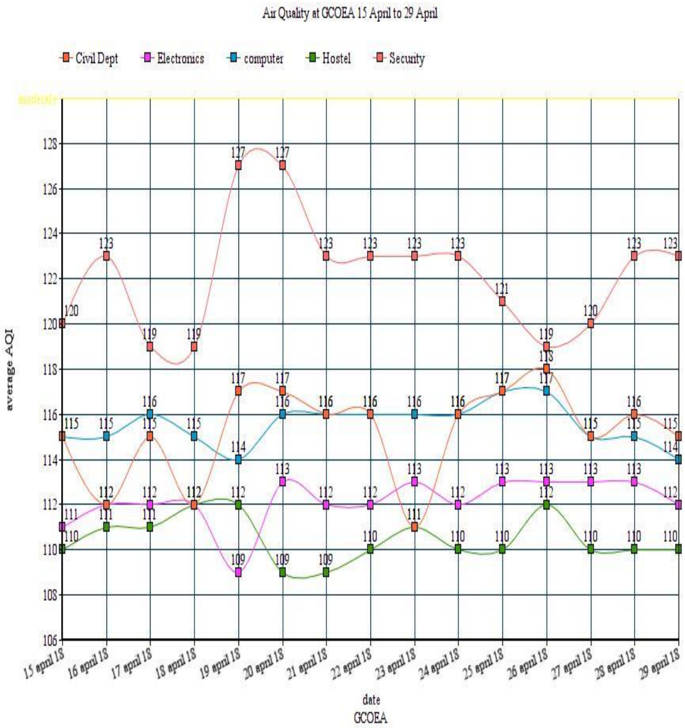


Chart -1: Air quality analysis at GCOEA 15 April – 29April 2018

In the campus, Ambient Air Quality monitoring carried out in five locations. The maximum value of 127 was reported security gate on 19th april 2018. average lowest AQI is reported at hostel.

3. CONCLUSIONS

In the month of April operation from April 15, 2018 to April 29, 2018, the modules successfully collected 360 hours of Temperature, Humidity, AQI data, respectively. The system performed with highest overall data completeness during the summer. To carry out perfect air pollution models, air pollution control, environmental impact and air pollution episodes, continuous air pollution monitoring using sensor network is the only solution. It is mandatory to expand the existing monitoring network. Many more on-line stations need to be established to get real time information about the spatial distribution of pollution and areas of acute pollution. To assess the operability of modules in different locations, selected all departments within the Government College of Engineering, Amravati including the Security gate and hostel to estimate how the environment would change in terms of humidity, temperature, AQI at distant places. Both the daily andbiweekly monitored values closely compared with actual field observations of system performance.As the results of the monitored data shows slight difference in readings within same campus there might be much more difference in same city among different zones so more stations need to establish by category wise i.e residential zone, commercial zone, industrial zone etc.

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