IoT BASED AIR QUALITY MONITORING SYSTEM

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Abstract* – *Air pollution is the largest environmental and public health challenge in the world today. It leads to adverse effects on human health, climate and ecosystem. Air is getting polluted because of release of toxic gases by industries, vehicular emissions and increased concentration of harmful gases and particulate matter in the atmosphere. Particulate matter is one of the most important parameter having the significant contribution to the increase in air pollution. This creates a need for measurement and analysis of real-time air quality monitoring so that appropriate decisions can be taken in a timely period. This paper gives the survey of various methods used so far to detect air quality along with overview of our project which results into real-time standalone air quality measuring parameters like temperature, pressure, relative humidity, PM 2.5, PM10. We make use of Internet of Things (IoT) which is nowadays finding profound use in each and every sector.

Index Terms – ***Air Pollution, Air Quality Monitoring System, Internet Of Things, Particulate Matter: PM2.5, PM10.***

I.INTRODUCTION

Air pollution is caused due to the presence of particulate matter, harmful materials and biological molecules in earth atmosphere. It has adverse impact on living organisms such as humans, animals, food crops and can also damage natural environment. It may result in respiratory diseases. Particulate matter is liquid or solid matter which is microscopic and suspended in Earth's atmosphere. Till now several studies have been done in environment monitoring domain using IoT. Researchers have monitored environmental parameters like Temperature, Humidity, Barometric air pressure, carbon monoxide, sulphur dioxide but the least attention is paid to the measurement of particulate matter. Anciently various methods were used to measure particulate matter, the results of which were used to develop improvised methods to measure the same. Some methods were inefficient and gave incorrect results. In this paper we will look at various methods and also introduce you to efficient real time standalone air quality measuring system.

II. SURVEY

A. Gravimetric Method

i) Particulate Matter (PM10)

To determine the particulate matter (PM10) in ambient air, the required materials are Respirable dust sampler, glass fibre filter paper 8X10 inch, balance, weight box, automatic volumetric flow control, flow-measuring device and top loading orifice kit.

Method: Inspect the filter for pin holes using a light table. Loose particles should be removed with a soft brush. Apply the filter identification number or a code to the filter if it is not numbered. Condition the filter in conditioning room maintained within 20-30° C and 40-50% relative humidity or in an airtight desiccator for 24 hours. Take initial weight of the filter paper (Wi) before sampling. Condition the filter after sampling in conditioning room maintained within 20-30° C and 40-50% relative humidity or in an airtight desiccator for 24 hours. Take final weight of the filter paper (Wf).

Calculation:

$$C\ PM10\ \mu g/m^3 = (Wf - Wi) \times 10^6 / V$$

where,
C PM10 = Concentration of Nitrogen dioxide ($\mu g/m^3$)
Wf = Final weight of filter in (gm)
Wi = Initial weight of g filter in (gm)
10^6 = Conversion of g to (µg)
V = Volume of air sampled (m^3)
Result would be experimental based PM10 value.

ii) Particulate Matter (PM2.5)

To determine the particulate matter (PM2.5) in ambient air, the required materials are Respirable dust sampler, filter paper, balance and weight box.

Method: An electrically powered air sampler draws ambient air at a constant volumetric flow rate (16.7lpm) maintained by a mass flow/volumetric flow controller coupled to a microprocessor into specially designed inertial particle-size separator (i.e. cyclones or impactors) where the suspended particulate matter in the PM2.5 size ranges is separated for collection on a 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. Each filter is weighed before and after sample collection to determine the net gain due to the particulate matter. The mass concentration in the ambient air is computed as the total mass of collected particles in the PM2.5 size ranges divided by the actual volume of air sampled and is expressed in $\mu g/m^3$. The microprocessor reads averages and stores five-minute averages of ambient temperature, ambient pressure, filter temperature and volumetric flow rate. In addition, the microprocessor calculates the average temperatures and pressure, total volumetric flow for the entire sample run time and the coefficient of variation of the flow rate.

Calculation:

1. The equation to calculate the mass of fine particulate matter collected on a Teflon filter is as below:

$$M2.5 = (Mf - Mi)\ mg \times 10^3\ \mu g$$

where,
M2.5 = total mass of fine particulate collected during sampling period (µg)
Mf = final mass of the conditioned filter after sample collection (mg)

Mi = initial mass of the conditioned filter before sample collection (mg)
10^3 = unit conversion factor for milligrams (mg) to micrograms (µg)
2. Field records of PM2.5 samplers are required to provide measurements of the total volume of ambient air passing through the sampler (V) in cubic meters at the actual temperatures and pressures measured during sampling. The following formula is used if V is not available directly from the sampler-

$$V = Q\ avg \times t \times 10^3\ m^3$$

Where,
V = total sample value (m^3)
Q avg = average flow rate over the entire duration of the sampling period (L/min)
t = duration of sampling period (min)
10^3 = unit conversion factor for liters (L) into cubic meters (m^3)
Result would be experimental based PM 2.5 value.

B. Using Raspberry Pi

This system was designed using Raspberry pi. The sensors are being used for detecting different environmental parameters like particulate matter, Carbon Monoxide, Carbon Dioxide, Temperature, Humidity and Pressure. The sensors are connected to Arduino Board and Raspberry pi is interfaced with Arduino Uno through USB cable. The data sensed by the sensors are continuously transmitted through Raspberry pi to the cloud over the internet because of its good network connectivity. The sensors DSM501A is a PM sensor whose output is PWM, used for measuring the particulate matter i.e. smoke and dust present in our environment, DHT22 and BMP180 are having digital outputs used for measuring temperature, humidity and pressure. The sensors, MQ9 (Gas sensor) as well as MQ135 (air quality sensor) are analog sensors used for measuring Carbon monoxide and carbon dioxide. This sensor-based Air quality monitoring system measuring the ambient pollution was highly accurate, affordable, easy to use.

C. ZigBee and Web System Based

This system collects data mainly through the ZigBee network and display data in a fixed receiving terminal. A new method is presented in this paper, the collected data is transferred to the Internet through the nod of ZigBee,

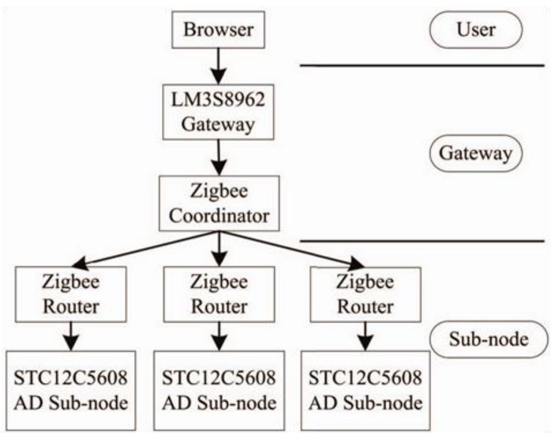

Fig.1. System structure diagram

In order to allow users to be able to observe the data though the internet, the data would be uploaded to the public Internet platform, the user could directly observe the data from the web browser. System set up a tree network based on ZigBee wireless communication technology, through the sensor nodes to collect and to form a sensor data frames, packed into the gateway device, to achieve environmental information monitoring.

D. MAQUMON

The Mobile Air Quality Monitoring Network (MAQUMON) provides a mobile air quality monitoring system which utilizes moving vehicles equipped with gas sensors to monitor a large area. The sensor node consists of a microcontroller, an on-board Global Positioning System (GPS) unit and a set of ozone (O3), CO, and nitrogen dioxide (NO_2) concentrations. The node is Bluetooth enabled, so it can send the data to the gateway in car. When the car moves, the device samples the sensors every minute and stores the data tagged with a location. When the car moves to a Wi-Fi hotspot, the gateway in the car will transmit the data to a server, and the data is processed and published on the sensor Map portal. MAQUMON provides a detailed record regarding air quality and pollutant dispersion within the region. But this monitoring system cannot immediately send the monitoring data back. Nor do the monitoring targets include meteorological information.

E. APOLLO

Propose an air Pollutants monitoring system, called 'APOLLO'. This system can simultaneously monitor many air pollutants (CO, NO2, volatile organic compounds (VOC), particulate matter (PM), carbon dioxide (CO2) while integrating the WSN technology into the system to transmit sensing data. In their study, however, the module prototype is established, but is not actually deployed for outdoor environmental monitoring.

F. Wireless Sensor Network

This method uses wireless sensor network technologies to receive and record monitoring data to complete a fully automatic air quality monitoring task. On the hardware side, different types of sensors and Octopus II wireless communication module are integrated to conduct Wireless communication under the ZigBee protocol. The back-end platform, controlled by the LabVIEW program, successfully communicates with users through sending them SMS messages. It also stores a large amount of data into the database via the MySQL program, so that experts can establish a prediction model of pollution diffusion based on the data. In addition, the actual monitoring data reveals small-scale pollution conditions in Gong Guan roundabout. The data can be applied to address the issues such as the impacts of motorcycles in the idle speed on air quality and the comparison between the -point monitoring data of Environmental Protection Administration (EPA) and the data collected by our proposed single monitoring network. Moreover, to achieve real-time monitoring, we expect the data of CO concentration could be displayed on the mobile communication devices, such as PDA, smart phones, and tablet PC for taking precaution to keep air pollution in check.

III. Using NodeMCU

We are implementing this method in our project which results into real time standalone air quality measuring parameters. The simplified diagram of the proposed system is demonstrated in Fig.2. ESP32 NodeMCU is the major node controlling our system. The sensors are being used for detecting different environmental parameters like
particulate matter PM2.5 AND PM10.

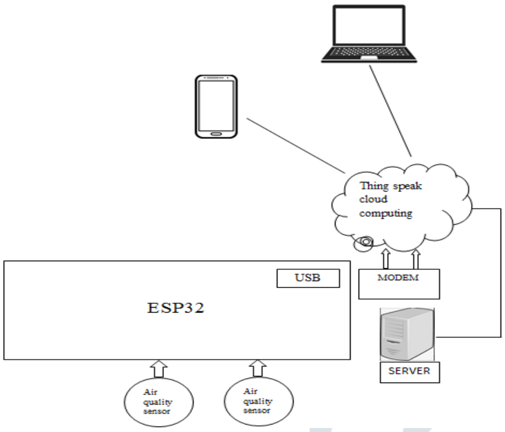

Fig.2. System Architecture

The sensors are connected to ESP32 NodeMCU and modem is interfaced with a NodeMCU. The data sensed by the sensors are continuously transmitted through NodeMCU to the cloud over the internet because of its good network connectivity. The sensors used are BME280 AND SDS011 for measuring temperature, pressure, relative humidity and particulate matter (PM 2.5 AND PM10) respectively. We make use of ThingSpeak to view the results.

IV. APPLICATIONS

The air quality monitoring system we designed gives efficient results. It is used for following purposes. To check pollutant levels in a traffic tunnel and ventilation shafts to confirm effectiveness. Also, Source apportionment of pollution-establishing where pollution of a particular profile is coming from. It is used for Mobile monitoring around an urban route to understand personal exposure and site selection for reference monitoring stations indoor air quality monitoring industrial perimeter monitoring to make this data available to common man.

CONCLUSION

Detection of temperature, pressure, humidity and most importantly PM2.5 AND PM10 has a major role in home, industry and air quality monitoring. The system we are implementing is rather very simple as compared to previous and existing air quality monitoring systems. This design has the advantages of stability and low-power consumption. The users can monitor real-time data and observe the changes in the data. This design will also play a significant role when the atmospheric conditions of a given area need to be checked which is not convenient for human to measure. System like this overcomes the problem of the highly polluted areas which is a major issue. It supports new technology and effectively supports the healthy life concept.

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