

AIRCOP – An Air Pollution Monitoring Device

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ABSTRACT - The rapid industrialization and technological developments have created many hazardous phenomena for humans. One such phenomenon is the Air Pollution which needs severe attention. So with the help of emerging technology, "Internet of Things" which is very helpful in monitoring and surveillance of an environment, a device has been developed for the remote monitoring of certain factors that are linked to air pollution. These certain factors which are considered for remote monitoring of air pollution are carbon monoxide(CO), General Air Quality, PM₁₀, PM_{1.0}, PM_{2.5}, temperature, humidity, atmospheric pressure, and wind speed. In this device, these factors are monitored using the low-cost sensors like DHT-21, MQ-135, MQ-7, BMP-180 and a self-designed anemometer. The data that are acquired from these sensors are then pushed to the cloud-based IoT platform known as the Thingspeak. Here the data is stored and visualized using the backend MATLAB analysis. This device could eliminate the large samplers and the chemicals that are being used for the analysis. In this device, AirCOP the reading can be taken for every 30 minutes interval so we could have continuous monitoring of our environment.

The name AIRCOP is derived from the two words in which the AIR represents the environment and the COP represents the officials those who find the criminals in an locality. Thus AIROP is device that is developed to monitor and find out the main pollutants in an area.

Keywords: Air Pollution, Suspended Particulate Matter, NodeMCU, Thingspeak and IoT.

INTRODUCTION

About 95% of the world's population lives in areas where the pollution levels exceed the WHO Guidelines. Around the globe 9 in 10 people breathe the polluted air. In the past decade, the deaths due to air pollution constitute about 12% of the overall global deaths.^[1] In India, particulate matter pollution has led to 10.6% of deaths in the years 2015 and 2016.^[2] According to the WHO, India has 14 cities out of the 15 cities that are listed as most polluted cities around the world.

Vehicular exhaust is responsible for about 70% of all CO, 50% of the hydrocarbons, 35% of the oxides and 30% of Suspended Particulate Matter (SPM). In India, the number of vehicles that run on the roads is about 5 million and out of these, 65% run on petrol. In major cities like Chennai, Delhi, Mumbai, Kolkata, etc, 800 to 1000 tons of pollutants are emitted into the atmosphere every day out of which 50% of them are emitted from automobile exhaust.

In India, the monitoring of air quality began in the year 1967 with the guidance of the National Environmental Engineering Research Institute, and in the year of 1974, the Central Pollution Control Board was established with 621 stations working in 262 cities and towns in 29 countries and 5 union territories. Here the main pollutant measured is Respirable Suspended Particulate Matter (RSPM) which includes the PM_{2.5}, PM₁₀, PM_{1.0}. Also, other factors like temperature, humidity, wind speed, wind direction were included in the air quality monitoring system.

Currently, the Pollution Monitoring is a time-consuming process and it is done using large volume samplers and other methods like Spectroscopy and Nondispersive InfraRed methods. For measurements of Particulate Matter, the Gravimetric or Beta Attenuation methods are followed and the readings are taken once every 24 hours. Spectroscopy is the method that is currently used to measure the CO content in the atmosphere.

CURRENT METHOD OF POLLUTION MONITORING

In the present day various physical and chemical methods are used in analyzing the environment i.e., monitoring the pollutant present in our breathing atmosphere. Some of those methods are

1. Gravimetric
2. TEOM
3. Beta Attenuation
4. Spectroscopy
5. Non dispersive Infrared
6. Solvent Extract

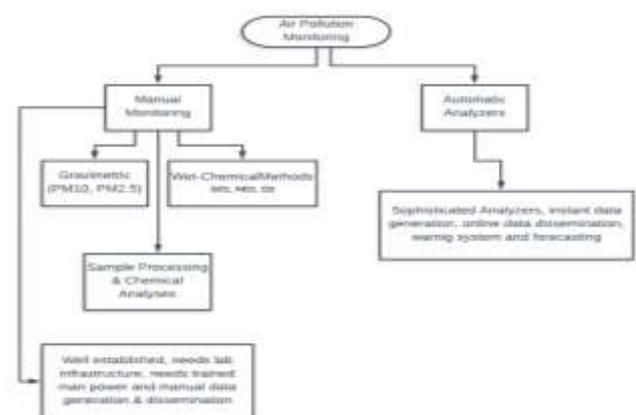


Figure 1 - Different Methods in Air Pollution Monitoring

In the above conventional methods, skilled labour is always needed to monitor/measure the pollutants. The total cost of the samplers may go around 50,000 rupees to 1,20,000 rupees. Thus these samplers cannot be used for continuous monitoring. The other wet chemical methods utilize some harmful chemicals like sodium thiosulfate, Sodium Arsenite, Sulphanilamide, etc. These methods also need some additional supportive devices like a vacuum pump, flow measuring devices, spectrometer, actinic glassware^[3].

The large volume samplers are the main equipment that are used to estimate the concentration of the particulate matter that is present in the environment. These samplers mostly work based on the light/lased scattering techniques.



Figure 2 - Currently used Samplers

THE SYSTEM ARCHITECHTURE

SENSOR NODE: The sensor Node has the sensors and the microcontroller unit. This is the physical setup that is to be placed in areas where the measurements had to be made. The main function of the sensor node is to collect the data regarding the environment with the help of different sensors and send it to the storage element.

IOT PLATFORM: IoT Platform is the place where the data from the sensor node is collected and stored. The main functions of the IoT Platform are data collection, data storage, data management, and data visualization.

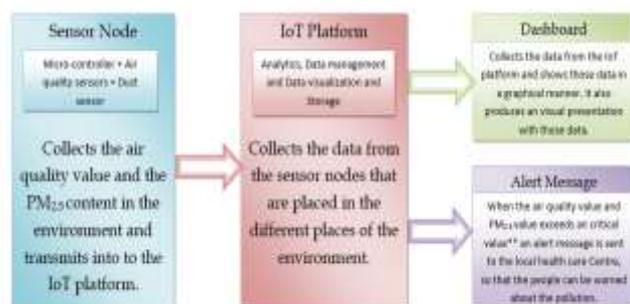


Figure 3 - Different Levels in the Working of Device

DASHBOARD: Dashboard is the means of data visualization. The outputs that are being stored in the IoT Platform is represented in a graphical manner which is very helpful in analyzing the environment in which the sensor node has been placed.

FACTORS THAT ARE MONITORED AND THEIR RESPECTIVE SENSORS

1) CARBON MONOXIDE: Carbon monoxide is one of the gases that does not have any colour or odour. It is released due to the incomplete oxidation of carbon compounds like the one during the burning of fossil fuels in an enclosed environment. It causes Carbon Monoxide Poisoning in humans further leading to headaches and vomiting, also it may damage our central nervous system. Exposure to a large amount of CO can make an individual lose his/her consciousness and leads to muscle weakness. For measuring the Carbon monoxide content in the environment (atmosphere), in this device, we have used an MQ-7 sensor which is based on a sensitive material called SnO₂. The SnO₂ has very lower conductivity in clean air.



Figure 4 - Carbon Monoxide Sensor

2. AIR QUALITY: Air Quality is the factor that determines the quality/purity of the air that we breathe. The sensors are used to monitor the air quality based on the different gases like NH₃, NO_x, alcohol, benzene, smoke, etc. NH₃ is an irritating and corrosive gas. It may lead to the burning of the nose, throat, and respiratory tract. Similarly, NO₂ can cause health problems like wheezing, coughing, cold, flu and bronchitis. Exposure to Benzene may lead to rapid or irregular heartbeat, tremors, irritation of the eye, stomach, skin, and lungs. For this MQ-135 sensor is used which gives out a very low output voltage with clean air and with impurities the output voltage changes.



Figure 5 - Air Quality Snsors

3. TEMPERATURE & HUMIDITY: The temperature and humidity are directly related with Air Pollution. With the increase in the greenhouse gases the temperature of the environment also increases. The humidity is the moisture content that is present in the atmosphere. When the moisture present in the atmosphere is high then the density of pollutants is also high. For sensing the temperature and humidity we have used the DHT - 22 sensor.



Figure 6 - Temperature and Humidity Sensor

4. PRESSURE: The atmospheric pressure also has some effects on the pollution levels in the atmosphere. Usually, in a high-pressure environment, the air is still and it does not move and so it leads to an increase in pollution level. In a low power environment, the air is mostly wet and the wind speed is also greater than the normal condition, so this causes the pollutant to disperse or it may be washed away by the rain. For measuring the pressure a BMP-180 sensor is used.



Figure 7 - Pressure Sensor

5. PARTICULATE MATTER (PM_{2.5}, PM₁₀, PM_{1.0}) Very tiny substances or particles that are suspended in the air are called as the Particulate Matter. Some of the particulate matters like PM_{2.5}, PM₁₀. Suspended Particulate Matter on exposure causes non-fatal heart attacks, irregular heartbeat, asthma, decreased lung

function and even death with lung and heart diseases.^[10] For measuring the different particulate matter, the optical dust sensor is used. This sensor works on the principle of **laser scattering theory**.



Figure 8 - Particulate Matter Sensor

6. ANEMOMETER: Anemometer is a device that measures wind speed. Here we have designed an anemometer that works based on the encoder property. For each revolution, one signal is encoded and by reading these signals, the wind speed can be calculated after proper calibration. When the wind speed is maximum then the pollutants are dispersed at a maximum rate. And so the pollutants are moved from the source to another environment very quickly. And when the wind speed is very minimum the dispersion of the pollutants is very limited and it leads to the accumulation of the pollutants in a single place itself. Place figures and tables at the places where they needed.



Figure 9 - Anemometer

7. MICROCONTROLLER UNIT: A micro-controller is used to collect the data and process the data from the sensors that are used for sensing the environment. Here we have used a **NodeMCU**, which is a Wi-Fi-based microcontroller. It works based on the ESP8266 Wi-Fi Soc. It has a RAM size of 128Kb and a memory of 4MB. It consists of 9 digital pins and a single analog pin.

DEVICE DESIGN

The device into which the sensors and the microcontroller is placed must have good airflow in it. It must also prevent the entry of the water and other bigger substances. The design of the device casing is shown below. The casing was

developed and designed keeping in mind the heat generated by the microcontroller. With the vent, the device may have good airflow in it. The square pyramid design prevents the entry of water into it.

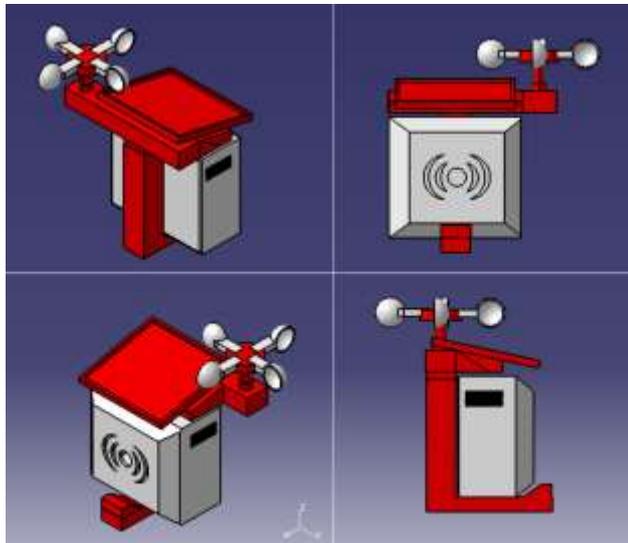


Figure 10 - Design of AirCOP

SOFTWARE DESCRIPTION

The NodeMCU can be programmed using two different languages. They are LUA SCRIPTING LANGUAGE and the ARDUINO based C LANGUAGE. Here the Arduino IDE is used to program based on the C language. For programming this AirCOP we have used the POST method for uploading the data to the Thingspeak Platform.



Figure 11 - Arduino IDE

ThingSpeak PLATFORM: The data collection, storage, and visualization are done using the ThingSpeak IoT Platform. It is an open-source platform with MATLAB facilities^[4]. The data is stored and retrieved by using the HTTP protocol through the internet.

OUTPUT

The data collected from the sensor is being sent to the cloud storage through the Thingspeak IoT platform. The

data visualisation has been made as shown in the below picture. This makes us to view the changes of the pollutant concentration in a course of time easily.



Figure 12 - Graphical Output Obtained from the IoT platform

CONCLUSION

Now with the fast-growing technology, air pollution monitoring has become a much easier job. This device AirCOP is designed in such a way that with a power supply and Wi-Fi/internet source it could eventually monitor our living atmosphere. This device built with low-cost sensors gives us the data with maximum accuracy and reliability. The design with which it is built also provides great support and efficient airflow. The data from the device can prevent humans from being exposed to the polluted atmosphere. So this could make the citizens realize how they are being responsible for the air pollution that is caused by them.

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