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Air Pollution Monitoring System

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Abstract: *Air pollution is the most important factor that affects the health and life of animals, humans and plants. Environmental conditions have a great effect on our comfort productivity and well-being. The current state of the air quality control for manufacturing industries in our country is based on taking a few samples on monthly basis, which means there is no information provided about time distribution of polluted materials intensity during the day. This paper puts forward an industrial air pollution monitoring system based on wireless sensor network system. That activates sensor data to deliver it within time constraints so that appropriate action can be taken. Acquiring these accurate real- time results allow agencies to take the necessary actions when pollution occurs. The focus of the analysis is on four substances also known as criteria air pollutants are particulate matter, Sulphur oxides, Carbon monoxide and nitrogen oxides. Using this system will reduce the effects of air pollution on human health and reduce damage to other aspects of the environment. Industrialization has increased the degree of automation which increases pollution by releasing pollutants into the atmosphere. A system is needed to monitor and assess the industrial pollution on everyday basis. Special attention is given to the factors affecting the health of organisms and the ecosystem. Industrial air pollution monitoring is the collection of information at different locations of an industry and at regular time intervals to provide the date which may be used to define current conditions. Due to the parameters complexity there are variations between different industries. The aim of the proposed system is in building a robust system to measure the industrial pollution so as to decrease human interference in monitoring to provide a healthy workspace for the workers. The system evaluates the industrial pollution continuously and alerts when there is an increase in emissions to take action to control it using wireless technology which is Internet of Things.*

Key Words: *Air pollution monitoring, IoT, Microcontroller, Sensor.*

1. INTRODUCTION:

Air pollution is a major issue in India. The air is getting more and more polluted over the years due to industrialization. Global warming is caused by natural and anthropogenic air pollution which is an environmental phenomenon. The particles of air pollution fall back to the earth and contaminate the surface bodies of water and soil. This can kill trees, plants, crops and reduce their yield. Air pollution is the permeation of biological molecules or harmful gases into the earth's atmosphere that causes diseases and damage to other living organisms. There has been an exponential growth of industries over the past quarter century. These industries are responsible to have caused complex and serious problems to the environment. Hence air pollution is one of the major concerns of the era, making it necessary for a system to monitor the industrial pollution. Industrial pollution monitoring is the collection of information at various locations of the industries taken at regular intervals of time to provide the data which may be used to define current conditions. The present air quality control is based on manufacturing industries taking samples one or few times a day. Our project proposes industrial air pollution monitoring system based on wireless sensor network system that enables sensor data to be delivered within time constraints so that appropriate action can be taken. Obtaining real-time data allows the regulation agencies to take necessary actions when the pollution increases permissible level. The data is displayed on the web page using an IoT module. Air pollution is the cause of many health issues for people working for the industries and the people living around it. It has been linked to high rates of cancer, stroke, heart disease and respiratory diseases such as asthma. Air pollution can also cause short term problems such as coughing, sneezing, headaches and dizziness. Small particulate matter like PM2.5 and PM10 pose high health risks as they can be breathed deeply into the lungs and may cross into the bloodstream. Air pollutants have less direct health effects when they contribute to climate change. Extreme weather, heat waves, food supply disruption and other effects related to increased greenhouse gases can have negative impacts on human health.

Air pollution affects the environment. Although many living organisms emit carbon dioxide, the gas is considered to be a pollutant when connected with cars, power plants, planes and other activities that include burning of fossil fuels like gasoline and natural gas. Carbon dioxide is the most common greenhouse gas that traps heat in the atmosphere leading to climate change. Human beings have pumped enough carbon dioxide in the atmosphere over the

past years to raise its levels higher than they have been for hundreds of years. Thus our project helps to monitor these pollutants that are emitted in the air from the industries so that the permissible levels are not exceeded by them.

2. LITERATURE SURVEY:

- **Towards a smart sustainable city: Air pollution detection and control:** It is a green IoT based system that depends on renewable energy. The Air Pollution Detection System (APDS) will be powered by a rechargeable battery that is fed by a small solar panel thus providing constant voltage for the system. This method doesn't contribute to the greenhouse effect. This system detects air pollution so that authorities will know the severity of the pollution and determine the cause. Using the information the authorities can take corrective measures like running emission tests on vehicles in highly polluted areas. The authorities can also use the data to have preventive plans like building industries away from populated areas and increasing green areas (1).
- **Remote air quality monitoring using MyRIO- LabVIEW:** The aim of this product is to remotely monitor the air quality within buildings. The implementation of air quality monitoring using LabVIEW has been implemented in many areas. The MyRIO and LabVIEW can be used to check physical parameters and can be used as a portable detection system where data is remotely viewed by a user. The data can also be saved in Microsoft Excel for future analysis. The parameter that will be examined in this project is the CO rate in a selected buildings at three locations. The hardware consists of MQ-7 gas sensor, Arduino mega and MyRIO controller. The sensor will detect the CO level and LabVIEW will save the data to a local file. By accessing the folder inside MyRIO the user can get the data. All this will be done remotely. The data can be examined easily by a user at a location within the building (2).
- **Implementation of Air Pollution Supervision using LabVIEW:**There are two main stages, first is the extraction of useful feature from the gas and second is the design of classifier using the features that are extracted. The resistances of the sensitive layer is taken from the data of each sensor. LabVIEW is used to calculate and plot the variation of these parameters w.r.t. time. LabVIEW is a graphical interface and easy for the user. The system is used to report the combination of multi sensors and the appropriate signal processing. LabVIEW is used for acquiring signals and in measurement analysis (3).

3. MATERIALS:

Table 1. Components used.

HARDWARE USED	SOFTWARE USED
• ESP32 Microcontroller • SDS011 (PM2.5 and PM 10) Sensor • MQ7 (CO) Sensor • 110602 (SO2) Sensor	• ESPlorer • ThinkSpeak • Android Studio

SYSTEM DESIGN:

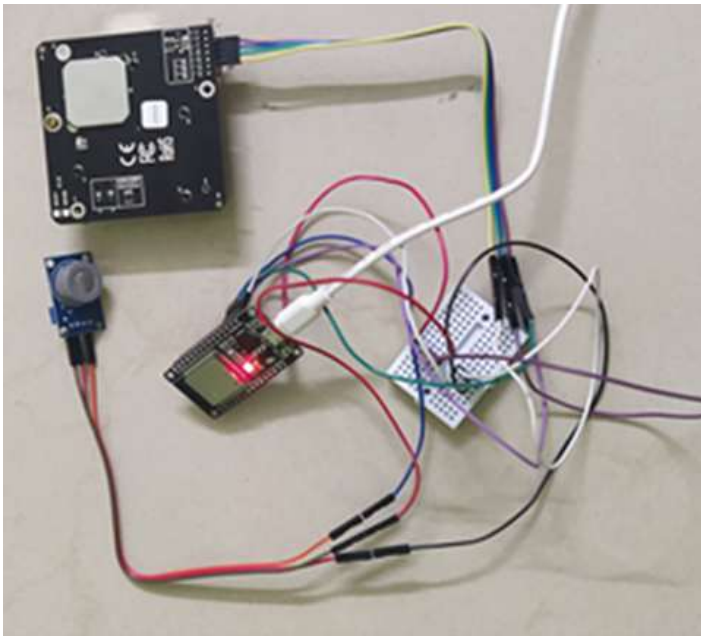

Figure 1.Circuit Connections

Figure 2. Mobile application display.

Figure 3.Data received on the mobile application from the particular sensor.

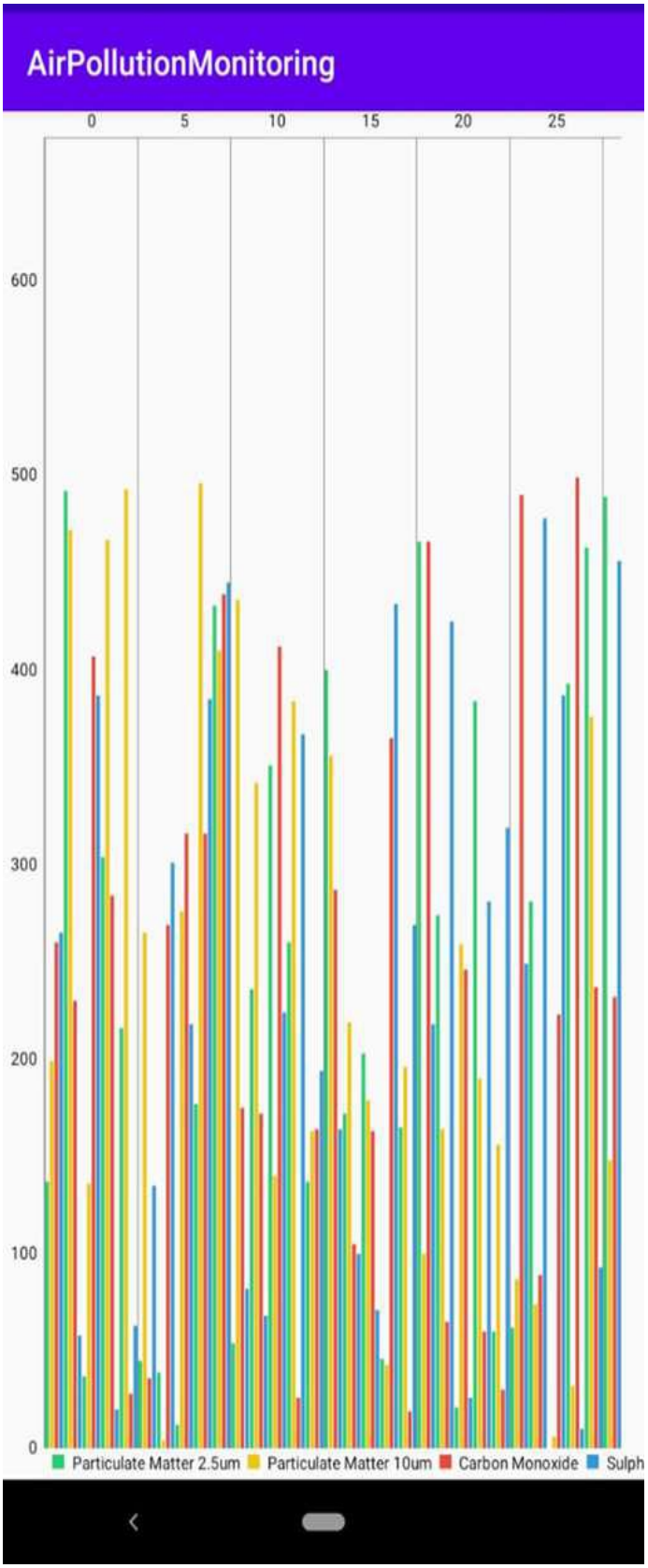

Figure 4.AQI graph of all the measured pollutants.

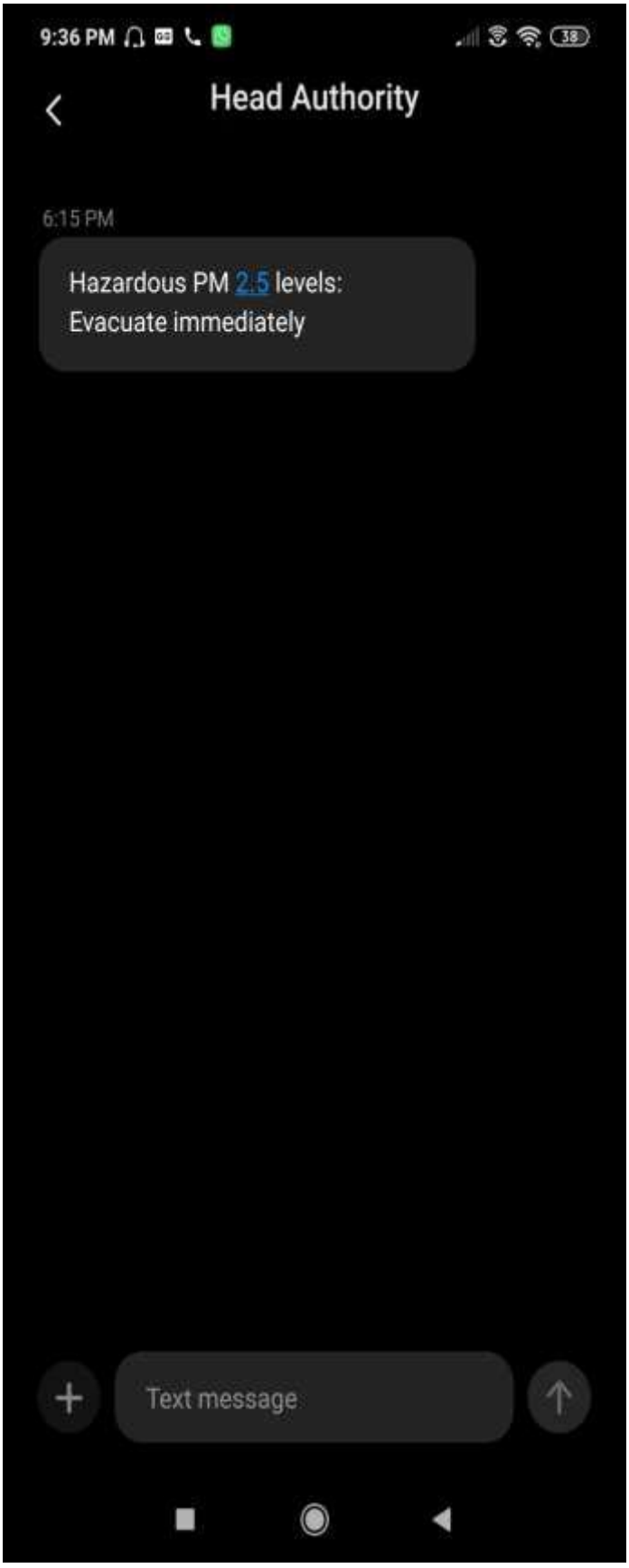

Figure 5.SMS received when high levels of pollutes measured.

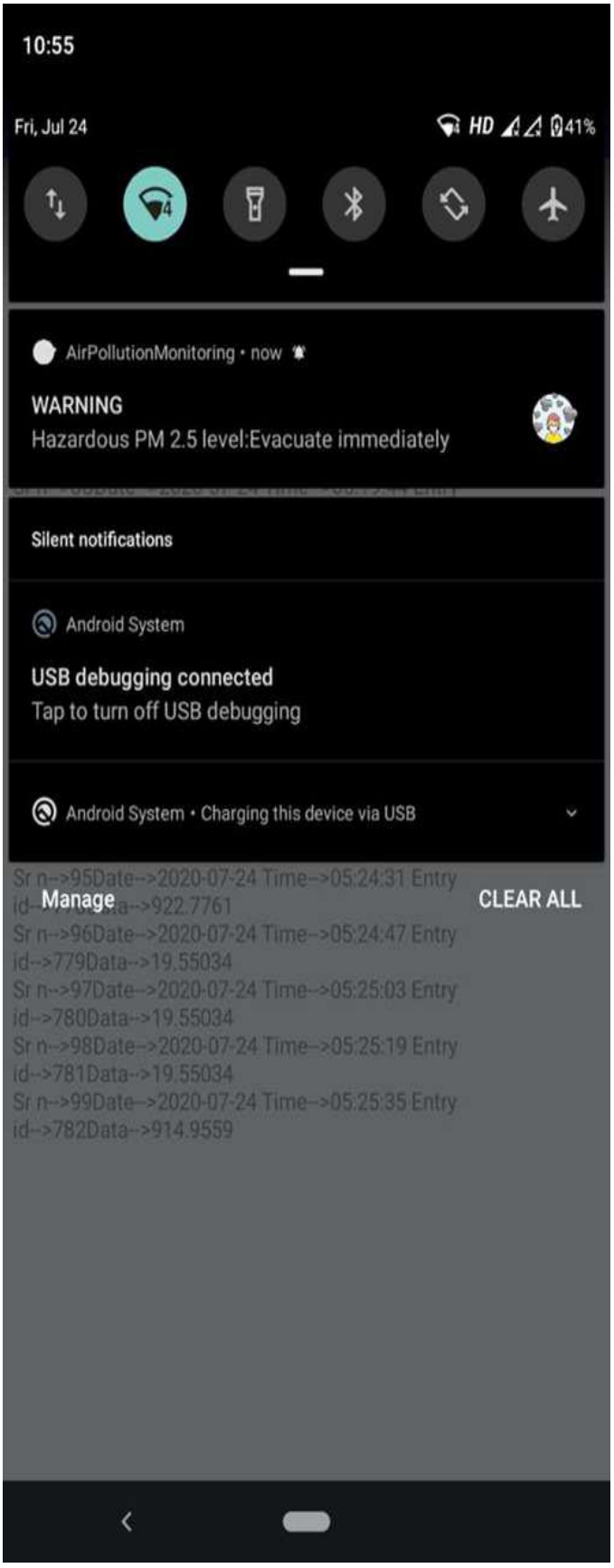

Figure 6. The notification received when the pollutants level increases above the permissible levels.

3. CALCULATION OF AQI:

Primarily two steps are involved in formulating an AQI:

(i) formation of sub-indices (for each pollutant) and
(ii) aggregation of sub-indices to get an overall AQI.

Formation of sub-indices ($I_1, I_2,....,\ I_n$) for n pollutant variables ($X_1, X_2,...., X_n$) is carried out using sub-index functions that are based on air quality standards and health effects. Mathematically;

$$I_i = f\ (Xi), \qquad i = 1, 2, \ldots, n$$

Each sub-index represents a relationship between pollutant concentrations and health effect.

Aggregation of sub-indices, I_i is carried out with some mathematical function to obtain the overall index (I), referred to as AQI.

$$I = F\ (\ I_1,\ I_2, \ldots.,\ I_n)$$

The aggregation function usually is a summation or multiplication operation or simply a maximum operator.

Sub-index function represents the relationship between pollutant concentration X_i and corresponding sub − index I_i. It is an attempt to reflect environmental consequences as the concentration of specific pollutant changes. 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 (C_P); as based on 'linear segmented principle' is calculated as:

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

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
I_P = Pollutant concentration.

BLOCK DIAGRAM:

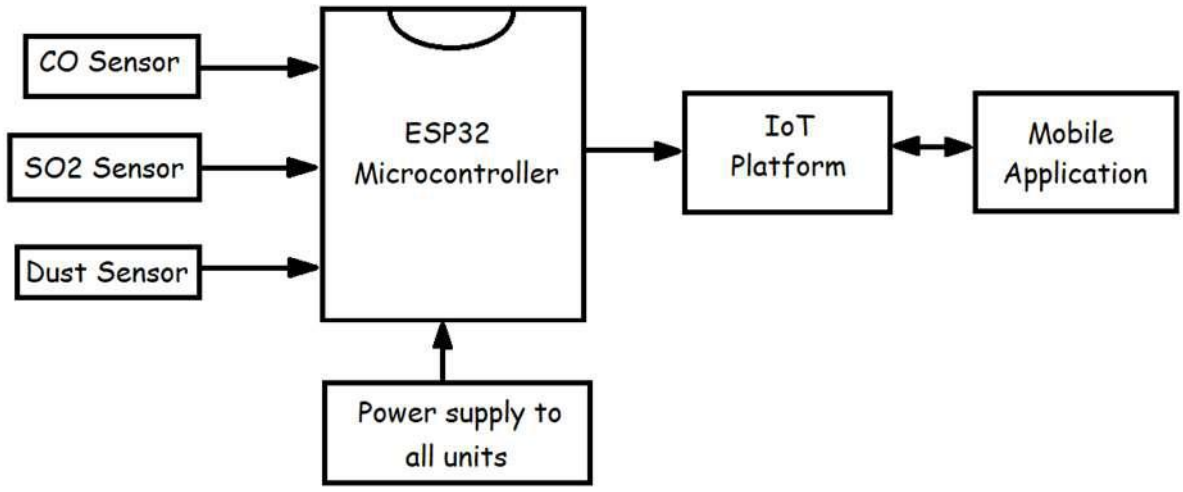

Figure 7. Block Diagram.

The block diagram consists of the ESP32 microcontroller and all the other components interfaced to it. The end product is the Mobile Application that is going to be used by the users. The other components are the sensors and the IoT platform. The sensors continuously monitors the surrounding environment and real time data is given to the ESP32. Here the ESP32 calibrates the data and gives it to the IoT platform via the inbuilt Wi-Fi module present in it. Using the

IoT platform the data is displayed on the Mobile Application. If the monitored data levels exceed the permissible levels the user will be altered and the required actions can be taken. The programming language used is Micro Python. Micro Python is a form of Python especially for microcontrollers. We use Micro Python as it is easier to understand and opens possibilities for rapid prototyping and opportunities for improving code maintenance and portability. It has User-friendly Data Structures, Extensive Support Libraries and also has Open Source and Community Development.

4. IMPLEMENTATION DETAILS:

The MicroPython firmware is added to the ESP32 microcontroller. Once this is done we preform two steps i.e. getting the device in the bootloader mode and secondly you need to copy across the firmware. And after doing so the microcontroller is ready for executing the MicroPython codes. Once the above steps have been performed the program can be written and debugged using the Esplorer software. Here we can make changes in the program if needed in the later stages. The sensors are connected to the microcontroller and we run the code to get the data through the sensors. The data from the sensors are displayed on the Esplorer. For the data to be available to user from any location we use IoT. We connect the microcontroller to Wi-Fi so it can communicate with the IoT platform and display it on the Mobile Application. We use Thingspeak as the IoT platform. Data from the sensors is sent to the Thingspeak website using a specific channel that is assigned to it. This data is store in the website in JSON format. When the user request for the data, the mobile application has to send a JSON request to access the JSON file. In return the website sends a JSON response which is read by the mobile application and displayed on the UI. The Mobile Application displays the names of the air pollutes being measured by the sensors. When the button of the desired pollutant is clicked a new activity is opened and the data measured by the senor will be displayed. Along with the respective readings of each sensor the air quality index is also measured using the data from each sensor. The person in-charge will also be notified via SMS and mobile application notifications, if the readings from the sensor cross a certain permissible level.

5. CONCLUSION:

The objective of this project is providing an automatic way to continuously monitor pollutes in the air which are the by-products from industries. The techniques currently used to monitor these levels are done manually and can't provide real time data as these use filter papers to detect the contents in the air. With our system there won't be any manpower needed as the system is fully autonomous. And will provide real time data and this data can be accessed from anywhere using the mobile application. Using the data from the sensors air quality index (AQI) will be calculated, if the AQI cross a certain permissible level, the person in-charge is notified via mobile application notification and SMS. Additional sensors can be added to the hardware based on the industrial needs. The sensors can be made wireless to cover a wider distance. Further this can be extended to roadside pollution monitoring and indoor air quality monitoring.

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