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IoT Based Low Cost Air Quality Monitoring Device

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Abstract: -

Background: In recent years, the air we breathe has been rapidly declining in quality, leading to the premature deaths of approximately seven million individuals worldwide each year. In light of these concerning facts, it is essential that citizens across the globe have access to transparent information about the quality of their environment. By doing so, they can make informed decisions before it is too late.

Methods: To address the above need, a prototype model for an air quality monitoring system has been designed. This system consists of a Node MCU ESP32 microcontroller, a MQ-2 gas sensor, MQ-135 gas sensor and a DHT-11 temperature and humidity sensor module and IoT.

Findings: The proposed integrated system can prove a very useful tool to carry out the steps to control pollution levels in the upcoming years when the pollution is increasing to a great alarming level. It is highly reliable and it can also be used at remote places. The sensors selected here provides accurate data for the system to carry out its function, and it can be said that the ratio of performance to cost of these sensors is quite high. The data collected by the sensors is transmitted to the processing module of the system, which is controlled by the microcontroller ESP32.

Novelty: The proposed model is very compact and low cost. It can provide the data when and wherever needed with the help of Internet of Things

Keywords: Shunt Air Quality, Internet of Things (IoT), Microcontroller ESP32, Real Time Monitoring, Low cost system, Arduino IoT Cloud

I. INTRODUCTION

In the present time, air pollution has posed a very significant threat to human health and it has become a very burning environmental issue which needs to be addressed immediately. Due to excessive exposure to pollution, several neurological, respiratory, dermatological, cardiovascular effects and various types of cancers have been observed amongst the children and adults. Breathing pollution free air is fundamental right of every individual.[1].
As per report generated in 2016 by World Health Organization (WHO), in 2016, a massive 90% of the global population was exposed to polluted air. Also the report indicated that more than half of the global population experiencing levels of pollution exceeding WHO's air quality guidelines. Additionally, 7 million deaths were recorded worldwide because of indoor and outdoor air pollution [1].
In the last 25 years, there has been a tremendous expansion of industries, which has resulted in significant environmental issues. The World Health Organization (WHO) has created guidelines to minimize the health consequences of air pollution on public health. These guidelines establish the maximum concentrations for various air pollutants, including, nitrogen dioxide (NO2), ground-level ozone (O3) and sulphur dioxide (SO2). The WHO's guidelines aim to reduce the negative effects of air pollution on human health [2]. As more and more pollution sources have emerged, there is a growing need for environmental pollution monitoring systems. These systems must have the capability to detect and quantify toxic chemicals rapidly in order to address the problem rapidly.

II. MATERIAL AND METHODOLOGY

In this section, a brief description of all the hardware and software used in present model has been discussed.

2.1 ESP32

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The MCU is rich in feature with integrated Wi-Fi and Bluetooth connectivity. It is robust, versatile and reliable with a wide range of applications It has ultra low power consumption and high level of integration. It is specially designed for Internet of Things (IoT) applications, wearable and mobile electronics. It is also the most integrated solution that occupies minimal Printed Circuit Board (PCB) area.

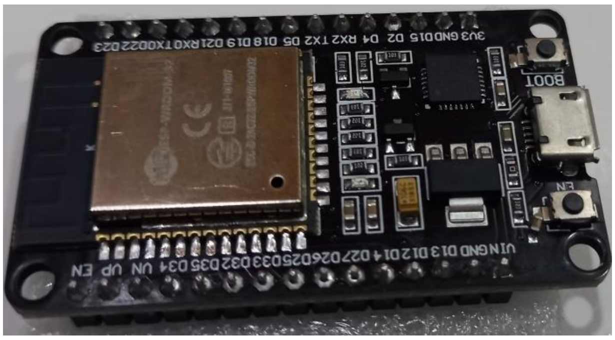

Figure 1. ESP32

In the present proposed model, it is the base station of the entire setup. Wi-Fi present in this module will enable the data to be sent on IoT cloud so that it becomes available as and when required even remotely. It also replaces microcontroller and GSM module by a common hardware All the sensors are connected to ESP32.

2.2 Liquid Crystal Display

Figure 2. Liquid Crystal Display

A 16 x 2 LCD display has been used for the display of the parameters. LCD has been used to maintain the simplicity of the project. It is the most basic module and it is quiet reliable which is very commonly used and has a very wide range of applications. It has voltage rating of 5V with green backlight.

2.3 DHT11 Sensor

Figure 3. DHT11

It is low-cost digital sensor for sensing humidity and temperature. Any microcontroller such as Arduino, Raspberry Pi etc can be easily interfaced to measure humidity and temperature instantaneously. The DHT-11 sensor is used to measure temperature in Celsius and humidity in percentage relative humidity (%RH) and the information is displayed on the serial monitor.

In the present model, it measures temperature and humidity and sends the data to NodeMCU ESP32 that processes it and sends to Arduino IoT Cloud.

2.4 MQ2 Sensor

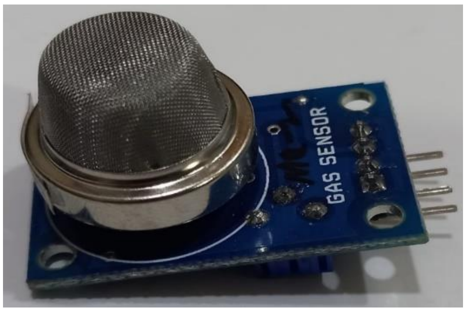

Figure 4. MQ2 Gas Sensor

It is an electronic sensor and it senses the concentration of various gases like carbon monoxide, methane, hydrogen etc. It has a sensing element the resistance of which changes when comes in contact with gas.

Here in the proposed model, it detects the concentration of carbon monoxide in the air and gives the analog output.

2.5 MQ135 Sensor

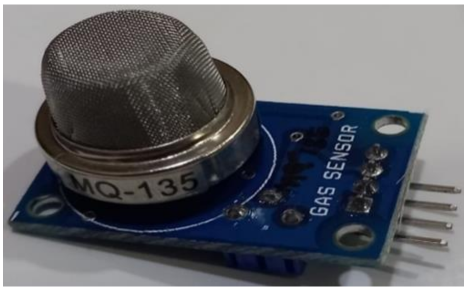

Figure 5. MQ135 Gas Sensor

The sensing material of this sensor is tin dioxide (SnO2). In clean air, the conductivity of this sensor is low. With the increase of the polluted gas and smoke in the air, the conductivity of the sensor increases.

In the present model, it measures AQI index and gives analog output.

2.6 Arduino Cloud

For creating and monitoring IoT projects, Arduino Cloud is used which is an online platform. A wide range of ESP32 / ESP8266 based development boards are supported by Arduino Cloud. In any IoT project, ESP chips fit very well. And also these chips can be programmed very well using Arduino language. ESP8266 and ESP32 boards includes features such as data monitoring, variable synchronization, scheduler, dashboard sharing are provided by Arduino Cloud .

In the present designed system, all data are stored in Arduino IoT cloud which can be retrieved and used whenever required. It can store data upto 15 days. Live data can also be monitored.

2.7 Proposed Model

The block diagram of the proposed system is shown in figure 6. A low cost system based on the internet of things is proposed. The entire system is controlled by node ``MCU ESP32. The sensors used are helpful in collecting data of harmful gases that are present in the environment and also sense temperature and humidity. The controller collects data and send it to the cloud with the help of in built Wi-Fi module and is also responsible for sending data to the IoT Platform publish the sensor data and keep an eye on it. That enables to track the data from anywhere in the world. The real time sensor data can be visualize in the form of graph, charts and numeric value.

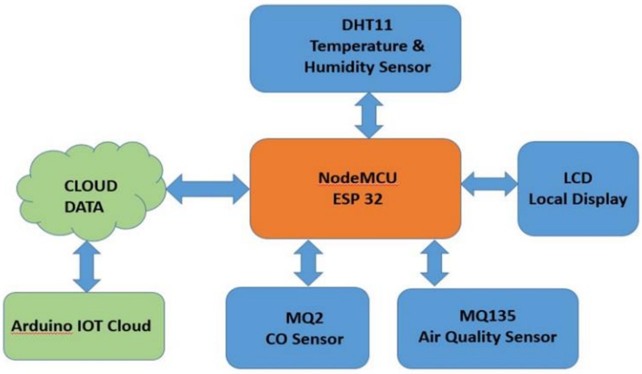

Figure 6. Block diagram of proposed system

Fig 8. shows experimental setup and it consists of ESP32, sensors, LCD. The VCC pin of the sensors MQ – 135, MQ – 2 and DHT11 is connected to 5V power supply. Grounds of all the three sensors and ESP32 are connected. Analog output pin of sensor MQ – 135 is connected to analog input pin GPIO 35 of the ESP32. Analog output pin of sensor MQ-2 is connected to input pin GPIO 33 of the ESP32. Data pin of DHT11 is connected to GPIO 32 pin of ESP32. For l2C Communication, SDA (Serial Data Line) pin of LCD is connected to GPIO 21 pin on ESP32 and SCL (Serial clock line) pin of LCD is connected to GPIO 22 pin on ESP32.

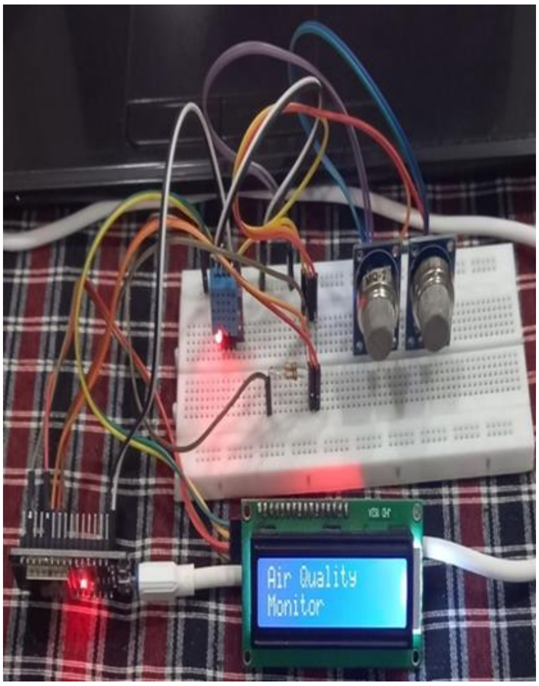

Figure 7. Connection

Figure 8. Experimental Setup

III. RESULTS AND DISCUSSION

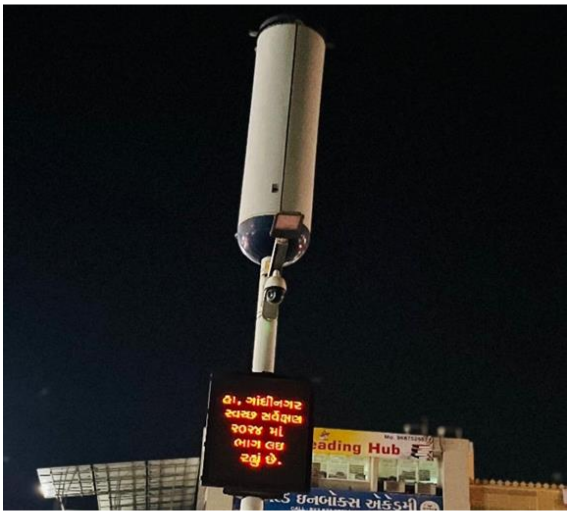

Figure 9. Existing System – Sector 6, Gandhinagar, Gujarat

The prototype implementation of air quality monitoring system has been done and compared with the live data of the actual installed system. Figure 9, 10 and 11 shows the real time monitoring of existing system at sector 6, Gandhinagar, installed by government of Gujarat. The results are taken on 10th May 2024.

Figure 10. Air Quality Index

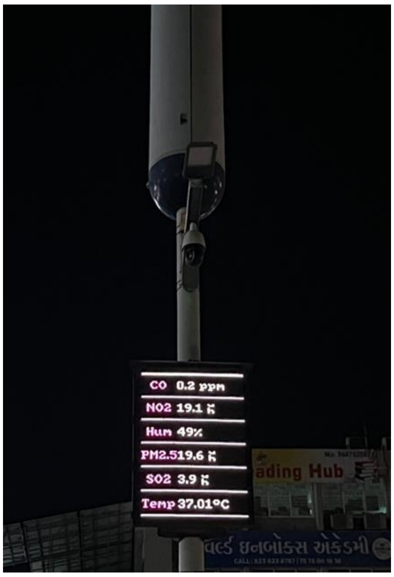

Figure 11. Other Parameters (CO, Humidity, Temperature)

Figure 12 and 13 shows readings obtained by using the proposed model. It shows real time monitoring of temperature, humidity and Air quality index and carbon monoxide respectively on LCD screen at sector 6, Gandhingar, Gujarat. It can be seen from figures that all the readings are similar with high accuracy.

Figure 12. LCD Data

Figure 13. LCD Data

Figure 14 shows the real time monitoring in Arduino IOT cloud showing live data of four parameters namely humidity, Temperature, AQI and CO.

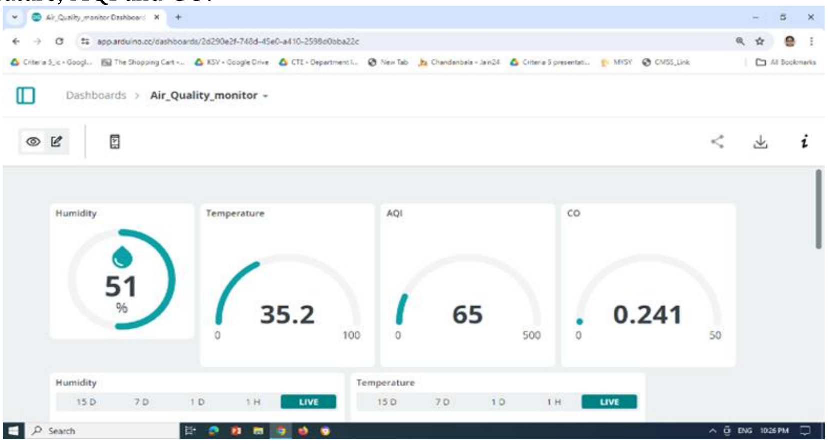

Fig. 14. Arduino Cloud Dashboard

Parameters	**Existing System (Sector 6, Gandhinagar, Gujarat)**	**Proposed System LCD Reading (Sector 6, Gandhinagar, Gujarat)**	**Arduino Cloud Dashboard (Proposed System)**
Relative Humidity (%)	49	51	51
Temperature (degree celcius)	37.01	35.2	35.2
Air Quality Index (AQI) (ppm)	65	65	65
Carbon Monoxide (CO) (ppm)	0.2	0.24	0.241

Table: 1 Different Parameters Comparison

The above table shows the comparison between the data obtained from air quality monitoring system installed by Government of Gujarat in sector 6 and one obtained from proposed model. We can see there is very little disparity between both the data and the proposed model outputs the same data at a very low cost.

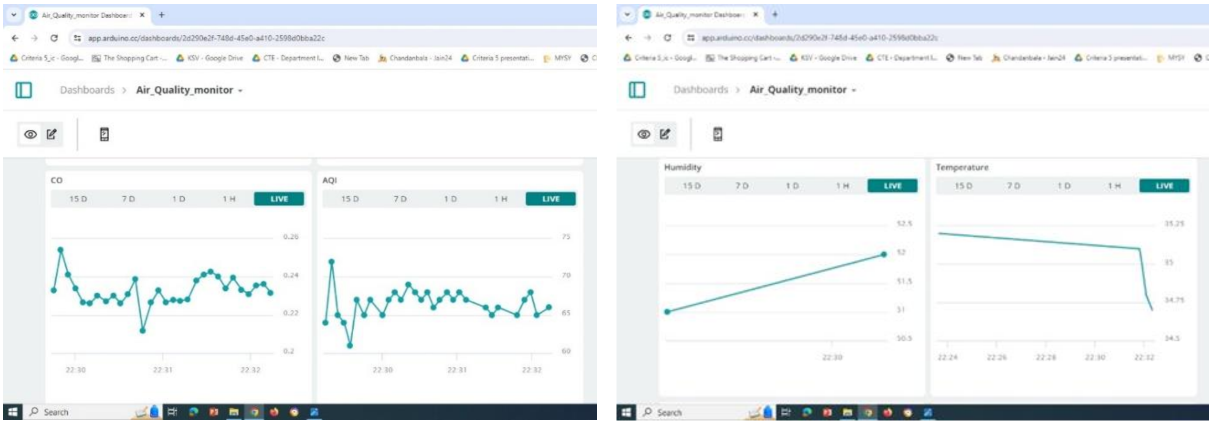

Fig 15. Different graphs consisting of real time air quality parameters in cloud

Graph 1. It shows of real time monitoring of CO in cloud.
Graph 2. It shows real time monitoring of air quality index in cloud
Graph 3. It shows real time monitoring of humidity in cloud.
Graph 4. It shows real time monitoring of temperature in cloud.

Parameters	Range/Value
Carbon Monoxide (CO)	0 to 50 ppm
Air Quality Index (AQI)	0 to 500 ppm
Temperature Range	0 degree celcius to 100 degree celsius
Relative Humidity Range	0 to 100 % RH
Power Supply	5V

Precision	High
Cost:	: ₹750 (INR)

Table: 2 System Specification

The proposed system can be applied at various areas such as
Indoor Air Quality Measurement: Several health diseases like Asthma, other heart and lung diseases and even cancer can be caused due to highly indoor polluted air these days. The air quality measurement system can compare it with ideal conditions and thus facilitate preventive measures.
Industries: Various air pollutants like particulate matter, various gases are released by industrial processes. Air Quality monitoring system becomes a necessity here to measure these parameters which ensures real-time data and also can automates the pollution control equipment. Here alerts and alarms systems can be installed so that quick actions can be taken. Unfortunate Accidents can be avoided by controlling leakages.
Hospitals: Patients can be sensitive to various air pollutants and other environmental conditions. Real time Air Quality measurement plays a vital role here in measuring various air quality parameters which can be controlled when needed.
Trend and Status Evaluation: Air Quality monitoring system can help in drawing trends over time that helps in forecasting future data. As a result of which preventive measures can be taken before worsening the situations.
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IV. CONCLUSION AND FUTURE SCOPE

The objective of this paper is to present a Real-Time Air Quality Monitoring System to ensure a healthy environment, which is vital for human well-being. The proposed system incorporates dedicated sensors that remotely gather data from any location, providing several advantages such as reduced cost, lower maintenance, and increased stability. One of the key advantages of the proposed system is its compact size. Instead of using a bulky combination of Wi-Fi and Arduino module to upload data to the internet platform, the system utilizes a single NodeMCU ESP32, resulting in significant cost savings. The system's design and data results demonstrate its utility, and real-time data can be accessed on the IOT Arduino Cloud from anywhere and anytime. The system is well-suited for long time monitoring of air quality in any area continuously. The system is well suited for continuous monitoring of air parameters in real-time, and the data collected by the sensors is processed and transmitted to a mobile application. Prompt actions can be taken with the help of the live results provided by monitoring system.
The potential future scope is that the model could be extended so that it can detect other harmful pollutants like Nitrogen Oxides (NO_x), Volatile organic compounds (VOC), Sulphur dioxide, Particulate matter (PM1,PM10 and PM2.5) that needs a check. Also the model can be connected to automated corrective measure circuit so that it can start and corrective measures can be taken instantly as soon as the pollutants level is crossed above pre-determined levels. Even the model can be extended to monitor indoor air quality parameters.

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