AIR QUALITY INDEX MONITORING

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Abstract

In the face of escalating industrialization and urbanization, the escalation of air pollution has emerged as a paramount concern impacting both public health and environmental sustainability. In response to this pressing issue, we introduce an innovative IoT-based Air Quality Monitoring System, leveraging sensor fusion technology to deliver real-time monitoring of crucial air quality parameters. This system seamlessly integrates diverse sensors, including MQ135, MQ7, and MQ2, to effectively measure key air pollutants such as carbon dioxide (CO2), carbon monoxide (CO), methane (CH4), smoke, and various volatile organic compounds (VOCs).

Furthermore, this cutting-edge system is equipped with an LED display, facilitating a localized hardware interface for users to directly access and visualize real-time air quality readings from the device. This feature significantly enhances convenience and accessibility, particularly in regions with limited internet connectivity or infrastructure.

By amalgamating sensor fusion technology with IoT connectivity, our Air Quality Monitoring System offers a comprehensive solution for monitoring and managing air pollution levels. This advanced system empowers governmental authorities, researchers, and the general public with actionable insights to formulate informed decisions and implement effective strategies aimed at mitigating the adverse impacts of air pollution on human health and the environment. Through proactive monitoring and intervention, our innovative solution strives to foster healthier and more sustainable communities, thereby safeguarding the well-being of both present and future generations.

INTRODUCTION

The phenomenon of air getting contaminated is called air pollution. Majorly there are two types of air pollution. First one is indoor air pollution and another is outdoor air pollution. The main reason for indoor air pollution is the usage of plant waste, coal for cooking purpose . Due to the industrialization and increased population growth the combustion of fossil fuels like coal, petroleum and natural gases increases for vehicle usage, generation of electricity in power plants which causes outdoor air pollution. As a results the air starts polluted exponentially.

Other reasons for air pollution includes use of pesticides in the agriculture farm, industry and factory wastes, operations on mining etc. Good air quality is the basic need for any living beings in the planet. World Health Organization said on report that 9 out of 10 people in the earth breathe contaminated air. As a result 5.5 million people are dying every year . Among that nearly 4.3 million of people died because of indoor air pollution clearly shows that indoor air pollution produces severe effects than outdoor pollution . Especially in Delhi nearly 30000 people died annually because of air pollution . Indoor air pollution causes diseases like 40% heart disease, 40% stroke, 11% as chronic obstructive pulmonary disease, 6% as lung cancer and 3% low respiratory problems with children. Outdoor air pollution causes diseases like 34% as stroke, 26% heart disease, 22% chronic obstructive pulmonary disease, 12% as low respiratory problem with children and 6% as lung cancer.

The Project aims to calculate real-time Air quality index with the help of arduino along with wifi module Esp8266 and gas sensors Mq135,Mq2,Mq7 which calculates the concentration of different harmful gasses in the environment, then we set a threshold and if the aqi rises above that level than the alarm system activates and tells that aqi exceeds the threshold.we are using blynkk platform for showing the real-time data on live server.

MQ135 gas sensor has high sensitivity to ammonia gas, sulfide, benzene series steam, also can monitor smoke and other toxic gases well.The Arduino Nano is a microcontroller-based device with 16 digital pins that can be used for various purposes. It can be used for almost every task, from minor to massive industrial-scale projects. It can also be used for prototyping and developing new applicationsThe MQ2 sensor is one of the most widely used in the MQ sensor series. It is a MOS (Metal Oxide Semiconductor) sensor. Metal oxide sensors are also known as Chemiresistors because sensing is based on the change in resistance of the sensing material when exposed to gasses .The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all WiFi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.

Literature Survey

The system proposed by **Anitha N; Anne Caroline S; Shalini P; Trisha V** aims to enhance the **[1]**quality of indoor air using Arduino UNO integrated with sensors. It employs Optical dust sensor and MQ-135 sensor to monitor dust, pollen, and smoke levels in the atmosphere. The collected data is utilized to analyze and calculate the Air Quality Index (AQI), which is then displayed on the LCD screen. If the AQI value surpasses safe limits (>400ppm), an alert is triggered, accompanied by blinking LEDs to signal the presence of harmful levels of air in the vicnity.

The main objective of the system. By **V. Gokul and S. Tadepalli** is to design and implement a Wi-Fi based plug and sense smart device for dedicated air pollution monitoring using Internet of Things simply called as IoT. The system designed on device to cloud architecture in IoT**[2]** for monitoring air pollution precisely. Once the sensor node reads individual pollutants composition and location coordinates, Air quality index (AQI) will be calculated using linear segmented principle with greater Vancouver AQI table and Max operator aggregation method. Based on AQI value, corresponding LED will be actuated for indication and health impact with precaution steps messages will be displayed on the screen. All those data will be pushed to thingspeak cloud storage an open source application programming interface for IoT based devices. These pushed data along with date and time can be retrieved as a separate excel sheet for future analysis. Through thinkview android app, real time pollution level with location can be visualized in terms of line graph.

This paper by **Moursi, A.S., El-Fishawy, N., Djahel, S. *et al*** proposes an Internet of Things (IoT) enabled system for monitoring and predicting PM2.5 concentration on both edge devices and the cloud. This system employs a hybrid **[3]**prediction architecture using several Machine Learning (ML) algorithms hosted by Nonlinear AutoRegression with eXogenous input (NARX). It uses the past 24 h of PM2.5, cumulated wind speed and cumulated rain hours to predict the next hour of PM2.5. This system was tested on a PC to evaluate cloud prediction and a Raspberry P*i* to evaluate edge devices' prediction. Such a system is essential, responding quickly to air pollution in remote areas with low bandwidth or no internet connection. The performance of our system was assessed using Root Mean Square Error (RMSE), Normalized Root Mean Square Error (NRMSE), coefficient of determination (R^2), Index of Agreement (IA), and duration in seconds. The obtained results highlighted that NARX/LSTM achieved the highest R^2 and IA and the least RMSE and NRMSE, outperforming other previously proposed deep learning hybrid algorithms

In this report by **S. Das, S. Chakraborty, D. Jana, R. Nandy and S. Bhattacharya [4]**, an IoT-enabled industrial air quality monitoring device is proposed. This device is enabled with an MQ-135 gas sensor for precisely monitoring the air quality and detecting the presence of foreign contaminants such as alcohol. The proposed device also uses a Node MCU ESP S266 Wi-Fi module to efficiently transmit real time data to a smart device (E.g. Smartphone) using an IoT platform.

In this paper **bySrivastava, H., Mishra, S., Das, S.K., Sarkar**, S **[5]**, a system has been developed for detecting the air pollution index with the help of Raspberry Pi based on IoT technology which sends an emergency notification (EN) if there are any chances that the air pollution may raise above the given threshold in the future is developed which measures physical parameters like temperature, humidity, dew point, wind speed and pollutants parameters like suspended particulate matter (SPM) and carbon monoxide (CO) are monitored, and the effect of these parameters in pollution level is being predicted for pollution monitoring. The main objective of this is to apply the machine learning algorithm for the prediction and analysis of gas sensors concentration levels, the effect of physical environmental parameters so that we can analyze the future concentration levels (AQI) level of the gaseous pollutant, and based on this, an emergency notification (EN) is sent to the public as well as the concerning authorities. A system is developed for monitoring and alerting in real time

This paper by **S. Dhingra, R. B. Madda, A. H. Gandomi [6]**propose a three-phase air pollution monitoring system. An IoT kit was prepared using gas sensors, Arduino integrated development environment (IDE), and a Wi-Fi module. This kit can be physically placed in various cities to monitor air pollution. The gas sensors gather data from air and forward the data to the Arduino IDE. The Arduino IDE transmits the data to the cloud via the Wi-Fi module. We also developed an Android application termed IoT-Mobair, so that users can access relevant air quality data from the cloud.

In this paper by **.Sujatha, B., Shivani, K., Sushma, G., [7],** an air quality monitoring system that operates in real time and independently is described with Parts per Million (PPM) and an indication of Air quality index (AQI) level. A unique method for better administration of data from PM2.5 Sensor collected and delivered by the NodeMCU (ESP8266) to the IoT platform and cloud computing. ThingSpeak can be used as a medium for reading results from the NodeMCU. As long as the NodeMCU can be connected to the Wi-Fi, the results can be monitored at any time.

The system presented in this paper by **R. K. Jha** is an advanced real time air quality reporting system supported with Internet Of things (IOT) architecture. The model presented here**[8]** uses a combination of the Arduino UNO software and hardware along with a Gas sensors - MQ135, MQ7 and dust sensor GP2Y1010AU0F which help in detecting gases like NO2, CO and PM2.5 while measuring their amount decently. Further, this research work monitor the Air Quality over an IOT analytics platform - ThingSpeak using internet connected with the hardware via the Wi-Fi module ESP8266.

Air particulate **[9] A. S. Ellares and N. B. Linsangan** matters were monitored using LoRaWAN gateways and sensing devices on the application dashboard. The monitoring devices adopted cloud-based technology in five chosen locations to monitor the quality of the air. To rapidly and effectively scan the reading and transmission of the data, a web server via The Things Network (TTN) was used. The dashboard was created using the Ubidots application. The device comprised a microcontroller, particle detection sensors, and a LoRa gateway on a cloud server. PM2.5, CO, CO 2 , NO 2 , temperature, and humidity were measured with the device. The CO and NO 2 values were monitored effectively. In the early evening, a higher AQI value was observed than at other times in the region.

The fundamental**[10]** purpose of this paper by **. Lavanya, P., Subbareddy** is to present a novel ecological monitoring system using a wireless sensor network with ESP8266 and SIM900. DHT 11 and MQ 135 sensors' sensed data would be directed to NodeMCU (microcontroller). The application discussed in this paper is sensor integration to an MCU with an ESP8266 Wi-Fi module and SIM900. Arduino IDE is used to program the microcontroller unit and integrate it to the Blynk server to monitor air quality and other atmosphere parameters.

The devices in this **[11]**system proposed by **Q. Aini, U. Rahardja, D. Manongga** are housed in a lab and built on an IoT (Internet of Things) architecture. Thermal parameters are also received automatically from the sensor with the right sensor, and user input data is collected. to process information in real-time in a distributed cloud setting. To do this, we use the Blynk Application Programming Interface (API). by using an automation system method to monitor sensor data in real-time allowing adjustments to dynamic temperature settings and regular user input. It is based on user feedback, power management guidelines, and sensor readings. The efficacy of the AQI is measured mathematically. The purpose of this study was to determine the level of cleanliness of the air from a room. Our Tests reveal that we have managed to save a total of 0.9 kWh while continuing to maintain the thermal comfort of our users.

This paper by **. U. Mittal, A. Pawar, G. Varshney[12]** presents an IoT based approach to monitor air quality in various outdoor and indoor environments. The proposed system uses NodeMCU with integrated Wi-Fi module along with necessary sensors for monitoring the air quality index (AQI) at different site locations. In addition to the measurement of AQI, parameters like humidity and temperature can also be recorded at the site. The system employs MQ-5 gas sensor for air quality sensing and DHT-22 sensor module for both temperature and humidity sensing. The sensed data is stored using cloud technology and ThingSpeak cloud platform is used to do so. The user is notified through an email alert as air quality reaches a certain threshold level.

This study done by **. F. Pradityo and N. Surantha [13]** discussed indoor air quality monitoring and controlling system that can monitor the air condition and control the air condition using an exhaust fan. This system used the IoT concept in conducting real-time monitoring of carbon dioxide and PM10. The proposed system has fuzzy controls that could adjust the working interval of exhaust fan automatically depends on the concentration of each pollutant. Experiment results show that the proposed system shows excellent performance in controlling indoor air quality in terms of pollutant concentrator, AQI, and processing time to remove the pollutants.

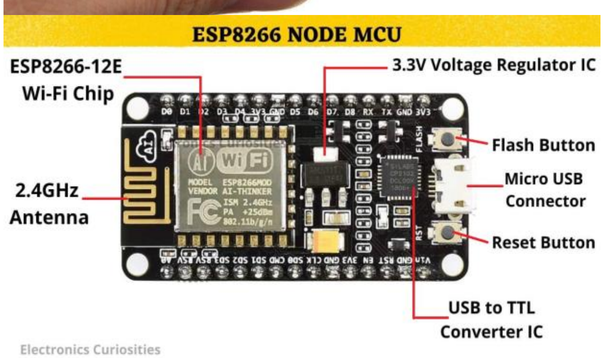
. This study developed by **M. Muladi, S. Sendari and T. Widiyaningtyas [14]** an air quality monitoring system in classrooms using Internet of Things technology on wireless LAN (WLAN) networks. The measured air quality is determined by the concentration of O2, CO, CO2 and NH3 gases at multiple measuring points in the classroom. The gas sensor is controlled by Arduino as a processor equipped with a wifi module and a real time clock (RTC). Sensor nodes are activated for 2 minutes to measure and send data and then put to sleep for 5 minutes. This operating mode consumes energy of 3,410 mWh or 42% less than full time operating mode. Data acquisition by each sensor node will be sent to the server using the HTTP protocol and displayed on web pages that can be accessed via the internet in real time. The results showed that the measurement of gas concentration at the sensor node was carried out accurately, real time and synchronously. The delay process for all sensors at each sensor node is about 2 minutes which is used for heating before making measurements.

implementing a system using IoT platform**[15] S. Jha, P. M. Nakade, M. P. Nazare, S. K. Chawla** which will sense the gases in real time 24X7 and in case of rise in levels of selected gases, it will communicate /alert every individual in the vicinity about the increased levels and accordingly rescue operation may be performed. This may save many lives. We are all aware that our capital city of Delhi is pronounced as one of the most polluted cities around the world recording an Air Quality Index of above 300 PPM. Also, industries nearby are adding to the increased levels. To continuously monitor the health of air, we shall deploy sensors at the desired locations and retrieve data in real time which will be then analysed using ThingSpeak.

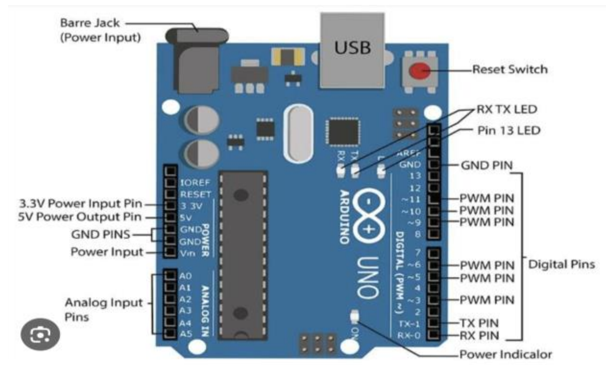
Proposed Work

Hardware Components

1)NodeMCU V3



2)Arudino nano



3)Mq 7

4)Mq2

5)MQ-135 Gas Sensor Module

6)Veroboard(KS100)

7) Connecting Wires

8)AC-DC Adapters

9)LEDs

10)Resistors

11)Power supply

12)Buzzer

SOFTWARE COMPONENTS

- Blynk
- Arduino IDE

Working Procedure:

Setup Hardware: Begin by gathering all the necessary components including Arduino Uno, ESP8266 Wi-Fi module, gas sensors (MQ135, MQ2), buzzer for the alarm, and an LCD display. Ensure you have the required jumper wires and a breadboard for prototyping.

Connect Components: Wire up the components according to their respective pinouts and connections. Here's a basic guide:

Connect the MQ sensors to the analog pins of the Arduino for reading sensor data.
Connect the ESP8266 Wi-Fi module to the Arduino for internet connectivity.
Wire the buzzer to a digital pin for activating the alarm.

Connect the LCD display to the Arduino for local data visualization.
Calibrate Sensors: Each gas sensor needs to be calibrated to ensure accurate readings. Follow the calibration procedures provided in the datasheets of the sensors. Calibration typically involves exposing the sensors to known concentrations of gases and adjusting their sensitivity.

Read Sensor Data: Write an Arduino sketch to continuously read analog data from the gas sensors connected to the analog pins. Utilize the analogRead() function to retrieve the sensor data.

Convert Analog Readings to Gas Concentrations: Use the calibration data and conversion formulas provided in the sensor datasheets to convert the analog readings into meaningful gas concentration values (e.g., parts per million, ppm) for each gas sensor.

Send Data to Cloud: Integrate the ESP8266 Wi-Fi module to establish a connection to a Wi-Fi network. Utilize libraries such as WiFi.h and HTTPClient.h to send the sensor data to a cloud server or IoT platform. Format the data in JSON format for transmission.

Display Data on LCD: Utilize the LiquidCrystal library to interface with the LCD display. Display real-time readings of gas concentrations on the LCD screen for local visualization. This provides immediate feedback to users without internet access.

Set Thresholds and Activate Alarm: Define threshold values for each gas pollutant beyond which the pollution levels are considered dangerous. Compare the real-time sensor readings with these thresholds. If any threshold is exceeded, activate the alarm (buzzer) to alert users.

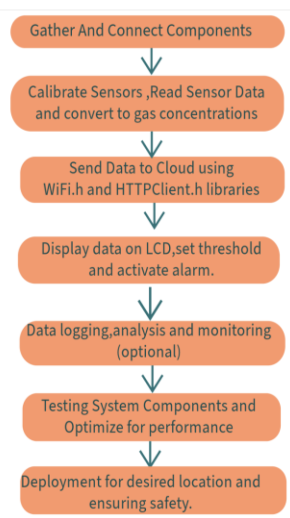
Data Logging and Analysis (Optional): Optionally, implement data logging to store the sensor data locally on an SD card or EEPROM for historical analysis. This allows for tracking pollution levels over time and identifying trends.

Remote Monitoring and Control (Optional): Implement remote monitoring and control features by sending sensor data to a cloud server. Users can access this data through a web or mobile application for real-time monitoring and receive alerts when pollution levels exceed thresholds.

Testing and Optimization: Test the system thoroughly to ensure accurate sensor readings, reliable Wi-Fi connectivity, and proper alarm activation. Optimize the system for power consumption and stability.

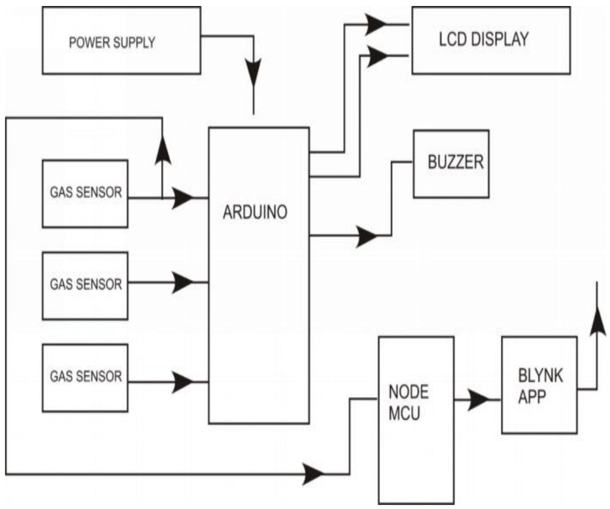
Deployment: Once testing is successful, deploy the air pollution monitoring system in the desired location. Ensure it is properly secured and protected from environmental factors.

WORKFLOW

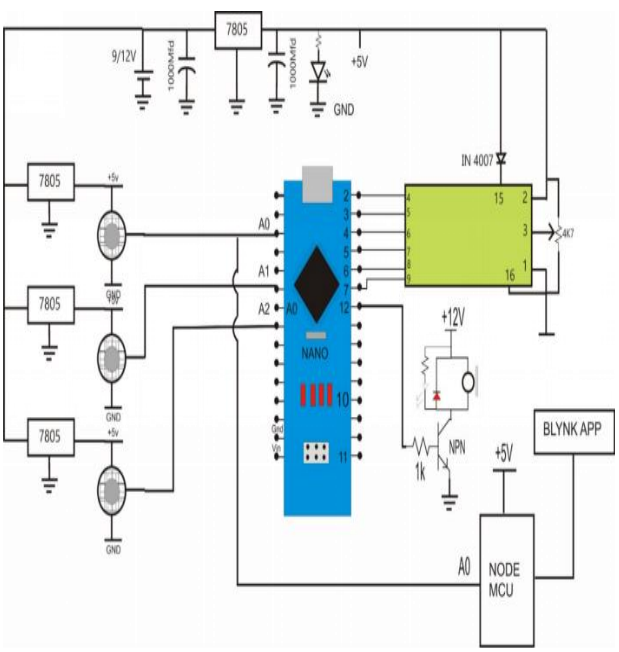


Workflow of Proposed model

Block Diagram



CIRCUIT DIAGRAM



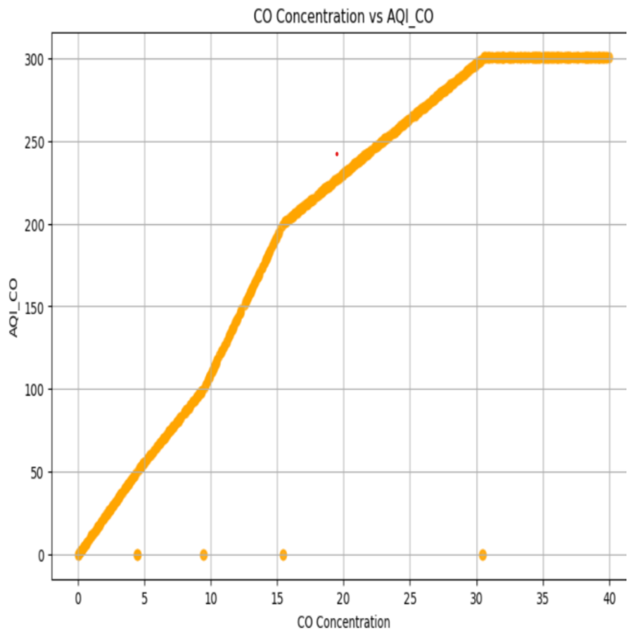
RESULTS

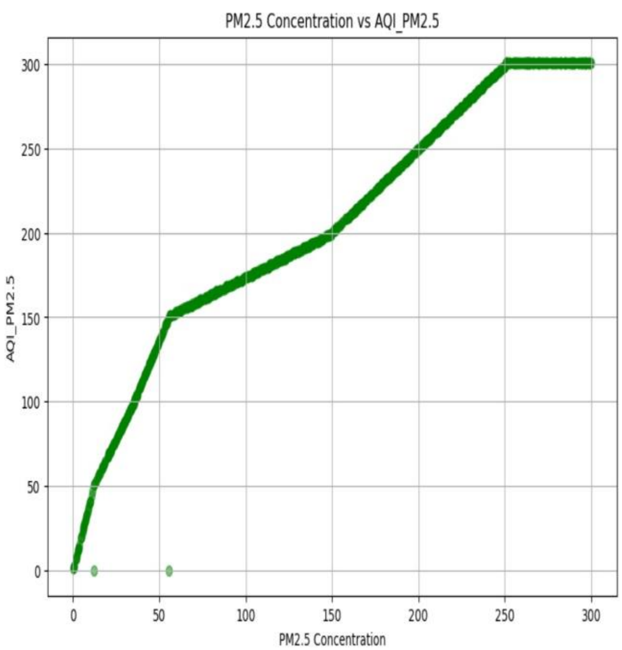
CONCENTRATION CONSIDERED

BREAKPOINTS

PM2.5-MQ135	CO-MQ7	AQI	EFFECT
0-12	0-4.4	0-50	GOOD
12.1-35.4	4.5-9.4	51-100	MODERATE
35.5-55.4	9.5-12.4	101-150	UNHEALTHY FOR SENSITIVE GROUP
55.5-150.4	12.5-15.4	151-200	UNHEALTHY
150.5-250.4	15.5-30.4	201-300	VERY UNHEALTHY
ABOVE 250.5	ABOVE 30.5	301-500	HAZARDOUS

DATA ANALYSIS





OUTCOME

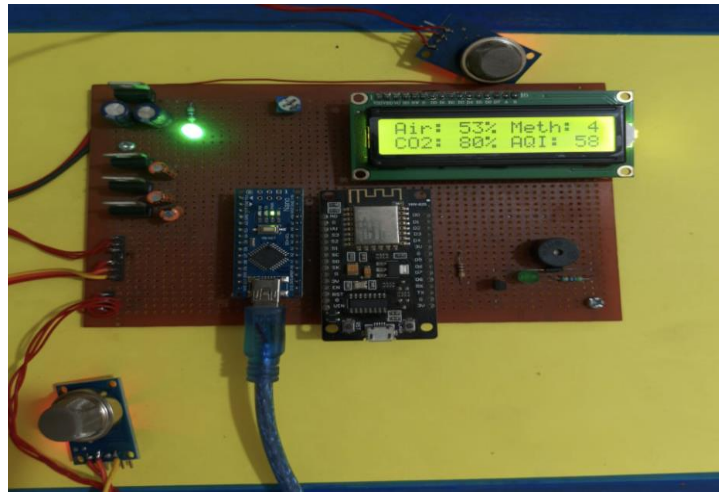


FIG A(AQI DISPLAYING)

The above image displays the three outputs displayed from the sensor readings i.e. MQ135(Air), MQ7(CO2) and MQ2(METH - methane) as well as the final Air Quality Index calculated (AQI) from the given 3 sensors.

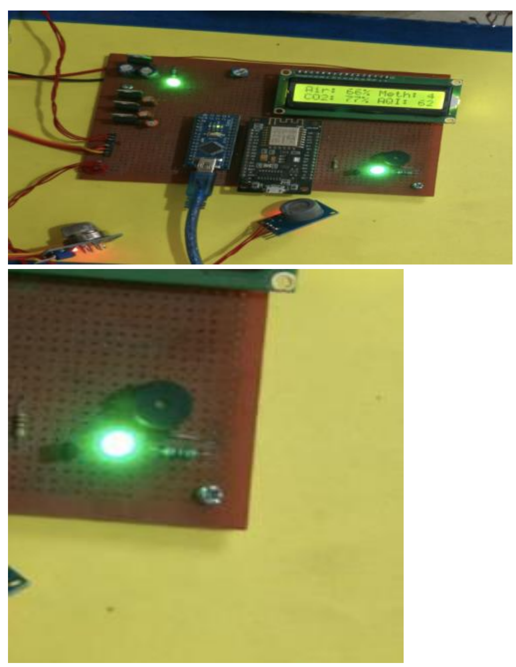


FIG B(BUZZER IMPLEMENTATION)

In the above image we displayed how we set the threshold of 60 ppm on pm2.5 sensor and then as the reading crossed 60 i.e. reaching 62 then the buzzer turns on denoting the crossing of threshold value by AQI.

CONCLUSION

In conclusion, the implementation of real-time air quality monitoring utilizing Arduino, ESP8266 WiFi module, and gas sensors MQ135, MQ2, and MQ7 presents a significant advancement in environmental sensing technology. By leveraging these accessible and cost-effective components, we have developed a system capable of continuously monitoring the concentration of various harmful gases in the atmosphere.

The primary goal of this paper was to calculate the Air Quality Index (AQI) in real-time, providing users with timely information about the air they breathe. Through the use of MQ sensors, we were able to measure the levels of gases such as carbon monoxide, methane, and volatile organic compounds, which are key indicators of air pollution.

Setting thresholds for acceptable AQI levels allowed us to create an alarm system that alerts users when pollution levels exceed predefined limits. This functionality enhances awareness and enables individuals to take proactive measures to mitigate exposure to harmful pollutants.

By integrating the Blynk platform, we were able to visualize and share real-time air quality data on a live server, facilitating accessibility and promoting transparency in environmental monitoring efforts. This feature also enables remote monitoring, allowing users to track air quality trends and make informed decisions regardless of their location.

Overall, this paper demonstrates the feasibility and effectiveness of using Arduino-based systems for real-time air quality monitoring. Future enhancements could include expanding the sensor array to detect additional pollutants and refining the alarm system for greater precision. Nonetheless, the current implementation represents a valuable contribution to the field of environmental sensing and holds great potential for applications in public health, urban planning, and pollution control.

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