VISVESVARAYA TECHNOLOGICAL UNIVERSITY

JNANA SANGAMA, BELAGAVI – 590018

A Project Report on

"Air Quality Sensing and Monitoring"

Submitted in partial fulfillment of the requirements for the award of degree of

BACHELOR OF ENGINEERING
IN
COMPUTER SCIENCE AND ENGINEERING

Submitted by

Rakshita R Devaraddi	**2VD20CS026**
Savio Rebello	**2VD20CS055**
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Under the Guidance of

Dr. Poornima Raikar

Dr. Venkatesh Shankar

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERINGKLS
VISHWANATHRAO DESHPANDE INSTITUTE OF TECHNOLOGY
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Certificate

Certified that the Project work entitled "**Air Quality Sensing and Monitoring"** is bonafide work carried out by **Savio Rebello, bearing USN:2VD20CS055** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Computer Science and Engineering of Visvesvaraya Technological University, Belagavi,** during the year 2023-2024. It is certified that all the corrections/suggestions indicated for internal assessment have been incorporated in the report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the Bachelor of Engineering degree.

Signature of the Guide	Signature of the HOD	Signature of the Principal
Dr. Poornima Raikar	**Dr. S. A. Sirdeshpande**	**Dr. V. A. Kulkarni**
Dr. Venkatesh Shankar		

Name of the Examiners:	**Signature with date:**
1.	**1.**
2.	**2.**

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“Task successful” makes everyone happy. But the happiness will be gold without glitter if we didn’t state the persons who have supported us to make it success. Success will be crowned to people who made it reality but the people whose constant guidance and encouragement made it possible will be crowned first on the eve of success.
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ABSTRACT

In the contemporary era of rapid industrialization, the surge in production has undeniably bolstered economic growth; however, it has also exacerbated environmental issues, particularly the rise in carbon dioxide (CO2) emissions. This phenomenon contributes significantly to global warming, depletion of the ozone layer, and poses serious threats to human health. The current methods employed to mitigate these challenges often fall short, and the reliance on manual monitoring can lead to lapses and negligence.

The proposed system involves continuous monitoring of pollution parameters in industrial settings. IoT devices would be strategically deployed to collect real-time data on various pollutants. Simultaneously, the system would gather comprehensive details about the industrial processes and their environmental impact.

The implementation of this IoT-based pollution control system offers several advantages. First and foremost, it provides a proactive approach to environmental management, preventing excessive pollution rather than merely reacting to it. Additionally, the automated nature of the system eliminates the risk of human error or neglect in monitoring and responding to pollution levels.

Furthermore, the proposed solution aligns with the global push towards sustainable and eco-friendly industrial practices. By incorporating IoT technology, industries can not only meet regulatory standards but also demonstrate a commitment to environmental stewardship. The potential long-term benefits include a reduction in carbon footprints, the preservation of natural resources, and safeguarding the well-being of both the environment and the surrounding communities.

In conclusion, leveraging IoT technology for pollution control in industries presents a viable and innovative solution to the pressing challenges posed by escalating pollution levels. By seamlessly integrating real-time monitoring, automated response mechanisms, and stringent authentication protocols, this proposed system promises to be a pivotal step towards achieving a harmonious balance between industrialization and environmental sustainability.

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CHAPTER 1

INTRODUCTION

1.1. Overview

The air quality sensing and monitoring project aims to assess and analyse ambient air conditions to ensure public health and environmental safety. Through the deployment of advanced sensor technology, this project seeks to gather real-time data on various air pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), Humidity and Temperature. By establishing a network of monitoring stations across targeted areas, including urban centres and industrial zones, the project aims to create comprehensive datasets for assessing air quality trends and identifying sources of pollution. Through collaboration with local authorities and environmental agencies, the project endeavours to develop effective strategies for mitigating air pollution and promoting sustainable development. With a focus on transparency and accessibility, the project intends to disseminate its findings to stakeholders, policymakers, and the general public through various communication channels, fostering awareness and encouraging informed decision-making towards achieving cleaner and healthier air for all.

1.2. Motivation

The motivation behind the air quality sensing and monitoring project stems from the critical need to address the increasingly concerning issue of air pollution. With urbanization on the rise and industrial activities expanding, air quality degradation poses significant health risks and environmental challenges. This project aims to empower communities and decision-makers with real-time data to understand, mitigate, and prevent air pollution's adverse effects. By deploying advanced sensing technologies, we can accurately monitor pollutant levels, identify sources, and implement targeted interventions. Additionally, enhancing public awareness and engagement through accessible data visualization and education initiatives is integral to fostering a culture of environmental stewardship. Ultimately, this project seeks to safeguard public health, preserve ecosystems, and contribute to sustainable development efforts.

CHAPTER 2

LITERATURE REVIEW

The escalating levels of pollution, propelled by factors such as rapid industrialization, urbanization, population growth, and increased vehicular activity, pose a significant threat to human health. In response to this pressing concern, the implementation of an Internet of Things (IoT) Based Air Pollution Monitoring System has emerged as a crucial measure to actively monitor and manage air quality through a web server.[1]

This innovative system is designed to not only track air quality but also to provide real-time updates and trigger alarms when pollution levels exceed predefined thresholds. The monitored parameters include harmful gases such as CO2, smoke, alcohol, benzene, NH3, and NOx. When the concentration of these gases surpasses a specified limit, an alarm is activated to alert users to potential health hazards. The IoT-based Air Pollution Monitoring System employs advanced sensors, specifically the MQ135 and MQ6, known for their ability to detect a wide range of harmful gases accurately. These sensors play a pivotal role in gauging the concentration of pollutants in the air, ensuring precise measurements. The system not only displays the air quality in parts per million (PPM) on a dedicated LCD but also offers a user-friendly interface accessible via a webpage. This dual presentation ensures that the air pollution status is easily comprehensible and readily available for monitoring purposes. By leveraging IoT technology, this system provides a seamless connection between the physical environment and the digital realm, facilitating remote monitoring and control. Users can access real-time air quality data remotely, enabling timely interventions and proactive measures to mitigate the impact of air pollution.[2]

The system is based on a smart sensor micro converter equipped with a network capable application processor that downloads the pollutants level to a personal computer for further processing. A wearable and wireless sensor system for real-time monitoring of toxic environmental volatile organic compounds was developed in. An air pollution geo-sensor network consisting of 24 sensors and 10 routers was installed to monitor several air pollutants in. The system provides alarm message depending on the detected pollution types in the field. The industrial pollution is controlled using the monitored data. But there is a problem in storing big data. There are several methods are used for real-time data storage. The Clean Wi-Fi network constantly monitors the air for pollutant gases, uses that information to feed a Big Sensor Data system, and uses the same data for the automatic configuration of the public Wi-Fi service, displaying information about the quality of the air to the user, and rewarding less

Polluted areas with a better service. That way it raises public awareness about the state of air pollution and how important it is to reduce it, promotes the use of renewable energies and brings Wi-Fi connectivity to the people. But using more electronic components may consume more electricity. Propose a new method that uses an interference alignment technique to mitigate interference effects in Wireless Sensor Networks. It overcomes the challenge arises in forming a data gathering network to maximize the network capacity. The system's operational prowess extends to generating timely and context-specific alarm messages based on the detected pollution types in the monitored field. This dynamic alert system serves as a proactive measure, enabling swift responses to potential environmental hazards. By providing actionable insights and alerting users to specific pollutant types, the system contributes significantly to fostering a safer and healthier living environment.[2]

Pollution is an important factor affecting the quality of the lives of millions. Most of the pollutants in the air are a result of emissions from vehicles, factories and natural occurrences like volcanic eruptions and forest fires. When people breathe in contaminated air, they are exposed to many health risks, such as cancer, premature death or asthma attacks. In industries, the polluted air is emitted in the atmosphere which in turn increases the temperature causing Global Warming. Also, the machines in the industries produce pollution like Noise pollution, Radiation, etc. the Radiation produced by the industries can cause cancer even for their labors. It is necessary to monitor pollution and keep it under control for a better future and healthy living for all. Due to flexibility and the low-cost Internet of things (IOT) is getting popular day by day. With the urbanization and with the increase in the industries pollution is caused.

In this paper, we propose a pollution monitoring and controlling system that allows us to monitor and control pollution in different industries of an area using GSM and IOT. The industrial pollution is controlled using the monitored data. But there is a problem in storing big data. There are several methods are used for real-time data storage. The Clean Wi-Fi network constantly monitors the air for pollutant gases, uses that information to feed a Big Sensor Data system, and uses the same data for the automatic configuration of the public Wi-Fi service, displaying information about the quality of the air to the user, and rewarding less Polluted areas with a better service.[2]

That way it raises public awareness about the state of air pollution and how important it is to reduce it, promotes the use of renewable energies and brings Wi-Fi connectivity to the people. But using more electronic components may consume more electricity. Propose a new method that uses an interference alignment technique to mitigate interference effects in Wireless Sensor Networks. To address the challenge of efficiently storing and managing the substantial amount of data generated by monitoring industrial pollution, a novel approach employing interference alignment techniques in Wireless Sensor Networks (WSNs) is proposed. This innovative method aims to mitigate interference effects, enhance data gathering efficiency, and maximize network capacity, while also considering the potential increase in electricity consumption associated with additional electronic components.[3]

The core idea revolves around the utilization of interference alignment, a sophisticated signal processing technique, to optimize the communication channels within the WSN. By aligning interference signals, the network can effectively reduce signal degradation, enhance the overall data transmission quality, and consequently improve the reliability of the gathered information. In the context of the Clean Wi-Fi network, this interference alignment technique can be strategically implemented to streamline communication between the pollutant gas sensors and the central data storage system. This approach not only ensures the accuracy and reliability of real-time pollution data but also facilitates the seamless integration of this information into the Big Sensor Data system. Furthermore, the proposed method leverages the gathered data not only for pollution monitoring but also for automatic configuration of the public Wi-Fi service. By dynamically adjusting the network parameters based on interference alignment, the system can optimize the utilization of resources and minimize signal disruptions, leading to a more robust and efficient Wi-Fi service. Despite the potential increase in electricity consumption due to the incorporation of additional electronic components.[4]

Implementing energy-efficient algorithms and protocols, along with interference alignment, will be crucial in ensuring that the benefits of the enhanced data gathering network outweigh the potential drawbacks. In conclusion, the integration of interference alignment techniques into Wireless Sensor Networks presents a promising avenue for addressing the challenges associated with industrial pollution monitoring. holistic and sustainable solution to environmental challenges.[4]

In today's fast-paced world, pollution remains a critical factor affecting the quality of life for millions. Predominantly emanating from vehicles, factories, and natural events such as volcanic eruptions and forest fires, pollutants in the air pose severe health risks, including cancer, premature death, and asthma attacks. Industrial activities not only contribute to air pollution but also result in noise pollution and radiation hazards, which can have dire consequences for workers' health, such as cancer. Therefore, it is imperative to monitor and control pollution effectively to ensure a healthier and more sustainable future. The advent of the Internet of Things (IoT) offers a flexible and cost-effective solution for pollution monitoring and control. As urbanization and industrial activities increase, so does pollution, necessitating innovative approaches to manage and mitigate its impacts. This paper proposes a comprehensive pollution monitoring and controlling system that leverages GSM and IoT technologies to monitor and manage industrial pollution in real-time. The proposed system integrates Wireless Sensor Networks (WSNs) with an interference alignment technique to mitigate interference effects, thereby maximizing network capacity.[4]

By forming an efficient data-gathering network, the system ensures accurate and timely pollution monitoring. Sensors placed strategically in industrial areas continuously collect data on various pollutants, which is then transmitted over a Clean Wi-Fi network. This network not only monitors pollutant gases but also feeds the data into a Big Sensor Data system for real-time analysis and storage. Interference alignment is crucial in overcoming the challenges of data transmission in WSNs, especially in dense industrial environments. By aligning the interference in such a way that it does not affect the primary data signals, this technique enhances the overall network performance and capacity. This allows for the seamless integration of multiple sensors and devices without compromising data integrity or transmission efficiency. A key feature of this system is its ability to generate timely and context-specific alarm messages based on the detected pollution types. This dynamic alert system serves as a proactive measure, enabling swift responses to potential environmental hazards. For instance, if high levels of toxic gases are detected, the system can immediately alert the relevant authorities and individuals in the vicinity, providing actionable insights and facilitating prompt remedial actions.[4]

Handling large volumes of data is a significant challenge in IoT-based pollution monitoring systems. To address this, the system employs advanced data storage methods that ensure efficient real-time data processing and retrieval. The use of cloud storage solutions allows for scalable and secure data management, making it easier to analyze trends and generate reports on pollution levels.[5]

An innovative aspect of this system is its integration with public Wi-Fi services. The Clean Wi-Fi network not only monitors air quality but also uses the data to optimize Wi-Fi performance. Areas with lower pollution levels are rewarded with better Wi-Fi service quality, thereby incentivizing pollution control efforts. This dual functionality not only promotes environmental awareness but also enhances the quality of public Wi-Fi services. The proposed pollution monitoring and controlling system offers a robust solution to the pressing issue of industrial pollution. By leveraging the capabilities of IoT, GSM, and advanced data storage techniques, the system provides real-time monitoring and control of pollution levels. The integration of interference alignment techniques ensures efficient data transmission, while the dynamic alert system enhances response times to environmental hazards. Additionally, the use of Clean Wi-Fi networks to disseminate air quality information and optimize public Wi-Fi services further underscores the system's multifaceted benefits. Through these innovations, the system significantly contributes to fostering a safer and healthier living environment, making a substantial impact on public health and environmental sustainability.[5]

Air Pollutants and Effects

Table 2.1 Effects of air pollution

Pollutant	Risk
CO	Fatigue, headache, impaired, vision, coma, brain damage, death
CO_2	Headache, Dyspnea, Tremors, Increased heart rate and blood pressure, Convulsions, Coma, Death
O_3	Lung disease
NO_2	Adverse effects on the respiratory system
SO_2	Adverse effects on the respiratory system
Particulate Matters	Lung disease
VOC	Eye, nose, and throat irritation Headache Damage to Liver, kidney and nervous system

Air Parameters sensing

Table 2.2 Parameter sensing

Parameter	Operating voltage	Measuring Range
Particulate Matter	5 V	10 to 10000 ppm
Carbon monoxide	1.5 V	10 to 10000 ppm
Carbon dioxide	3.3 V	10 to 10000 ppm
Temperature	3.3 V	-40 to +80 degree Celsius
Relative humidity	3.3 V	0 to 100 % RH

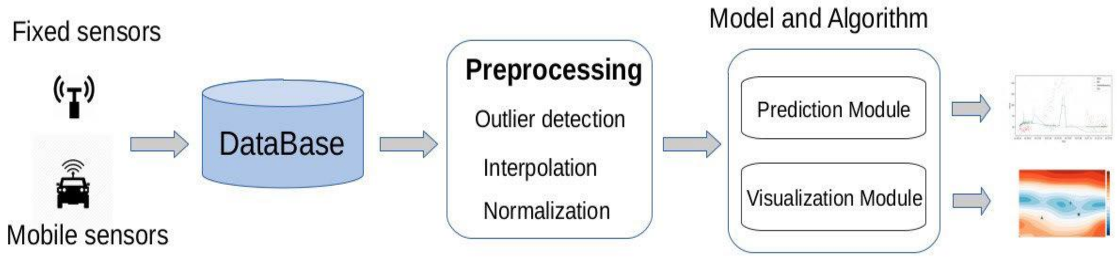


Fig: 2.1 The Structure of proposed system for monitoring and prediction of air pollution.

The regression models are commonly used in the area of air quality prediction. A multivariate linear regression model for predicting PM2.5 of short-period time is proposed in Zhao's work, which includes other gaseous pollutants such as SO2, NO2, CO and O3. As deep learning emerged as an effective method in many applications, time series data of air pollution based on different network models have been also extensively studied and developed. Novel models such as Long Short-Term Memory (LSTM) and Gated Recurrent Unit Network (GRU) have been proved to be a powerful sequential structure in predicting future values of air quality. Yi et al. proposed a deep distributed fusion network to learn the characteristics of spatial dispersion and capture all the influential factors that may have a direct or indirect effect on air quality. These aforementioned technologies fit non-linear models flexibly but usually being short of offering insight to the hidden mechanism. In addition, they have not shown to necessarily outperform classical regression models in many scenarios. There are also a lot of researches concentrate on approaches to model and simulate the pollutants for prediction. With a small amount of data set oriented in our project, we decided to take conventional regression models as our baseline methods because of computation efficiency, while yielding favorable results.[5]

Furthermore, the implementation of classical regression models provides a foundation for comparative studies, enabling the evaluation of more complex models against a well-understood baseline. This approach ensures that any improvements brought by advanced models such as LSTM and GRU are meaningful and justified by a significant performance increase. It also helps in identifying the specific conditions under which deep learning models may offer substantial benefits over traditional methods.[5]

Despite their simplicity, regression models offer transparency and interpretability, allowing researchers to understand the relationships between different pollutants and their combined effect on PM2.5 levels. This interpretability is crucial for developing effective mitigation strategies and informing policy decisions, as stakeholders can gain clear insights into the factors driving air pollution. Moreover, regression models are well-suited for smaller datasets, which are often encountered in initial stages of air quality monitoring projects or in regions with limited data availability. Their low computational requirements make them accessible for deployment on less powerful hardware, facilitating real-time predictions and on-the-edge processing capabilities in resource-constrained environments.[5]

In addition to the computational efficiency, the use of regression models allows for rapid prototyping and iteration, which is particularly beneficial in the early phases of research and development. This enables researchers to quickly test hypotheses and refine their models before committing to more resource-intensive deep learning approaches. Overall, while the emergence of deep learning has expanded the toolkit available for air quality prediction, the continued relevance and utility of conventional regression models cannot be overlooked. They provide a solid foundation for understanding pollutant dynamics, enable efficient and interpretable analysis, and serve as a reliable benchmark for evaluating the performance of more sophisticated models. In our project, leveraging these models not only ensures robust and explainable results but also positions us well for potential future integration of advanced machine learning techniques as our dataset grows and computational resources allow.[5]

CHAPTER 3

PROPOSED SYSTEM

3.1. Objectives

- Evaluate the impact of various pollutants on air quality to understand their effects on human health and the environment.

- Detect and identify specific pollutants present in the air, including carbon monoxide (CO), carbon dioxide (C02), Humidity and Temperature

- Monitor changes in air quality over time to identify trends and patterns, such as seasonal variations, pollution hotspots, and long-term shifts due to environmental or anthropogenic factors.

- Assess the potential health risks associated with exposure to different levels of air pollutants, particularly for vulnerable populations such as children, the elderly, and individuals with respiratory conditions.

- Raise awareness among the public about air quality issues, including the sources of pollution, health effects, and ways to mitigate exposure.

- Provide data and analysis to support the development of air quality regulations, policies, and interventions aimed at reducing pollution levels and protecting public health.

- Engage with local communities and stakeholders to gather input, address concerns, and collaboratively develop strategies for improving air quality.

3.2. Expected Outcomes

- Improved Public Health: By accurately monitoring air quality, the project aims to contribute to the reduction of air pollution-related health issues. This includes respiratory problems such as asthma and bronchitis, as well as cardiovascular diseases.
- Environmental Awareness: The project intends to raise awareness about the impact of air pollution on the environment. By providing real-time data on air quality, it empowers individuals and communities to make informed decisions.
- Policy Support: The data collected through the air quality sensing and monitoring project can serve as valuable evidence to support the development and implementation of air quality regulations and policies. Decision-makers can use this data to prioritize areas for intervention and allocate resources effectively.
- Early Warning System: By detecting changes in air quality in a timely manner, the project can serve as an early warning system for potential pollution events or environmental hazards. This allows authorities to take proactive measures to mitigate the impact on public health and the environment.
- Research and Innovation: The project provides a rich source of data for researchers and innovators to study the patterns and trends of air pollution. This can lead to the development of new technologies, strategies, and solutions to address air quality issues more effectively in the future.

CHAPTER 4

METHODOLOGY

To monitor air quality using the MQ2 CO & CO2 Sensor and DHT11 sensor with NodeMCU, Arduino Uno, or ATmega328P with a PCB, the methodology involves several steps. First, the sensors need to be connected to the microcontroller board. The MQ2 sensor detects various gases including CO and CO2, while the DHT11 measures temperature and humidity.

Once the sensors are connected, the microcontroller board is programmed to read data from these sensors periodically. This data is then processed and analyzed to determine the air quality parameters such as the levels of CO, CO2, temperature, and humidity.

The microcontroller board is then connected to the internet using Node-MCU, Arduino Uno, or ATmega328P with PCB. It sends the collected data to the ThingSpeak server, which acts as a data repository and visualization platform.

On the ThingSpeak server, data is displayed in real-time graphs and charts for easy monitoring. Additionally, email notifications can be set up to alert users when certain thresholds for air quality parameters are exceeded.

In summary, the methodology involves sensor connection, data collection, processing, and transmission to the ThingSpeak server for visualization and monitoring. Email notifications are utilized for timely alerts, providing an efficient means of monitoring air quality.

4.1 System Architecture

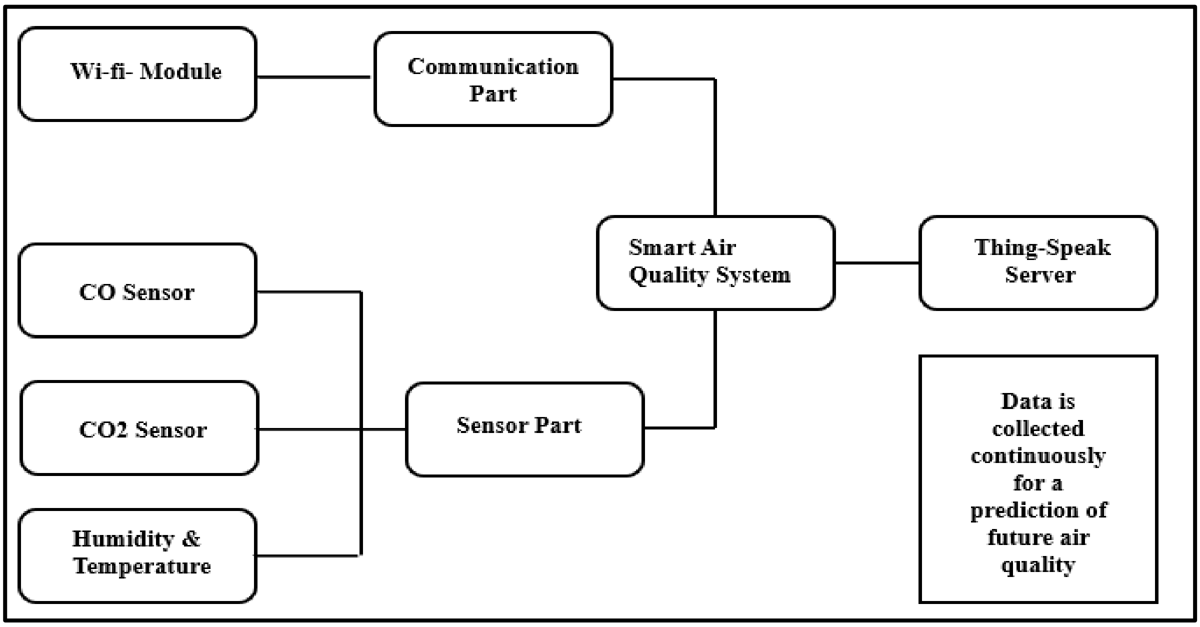


Fig 4.1 System Architecture of Air quality sensing and monitoring

4.2 Block Diagram

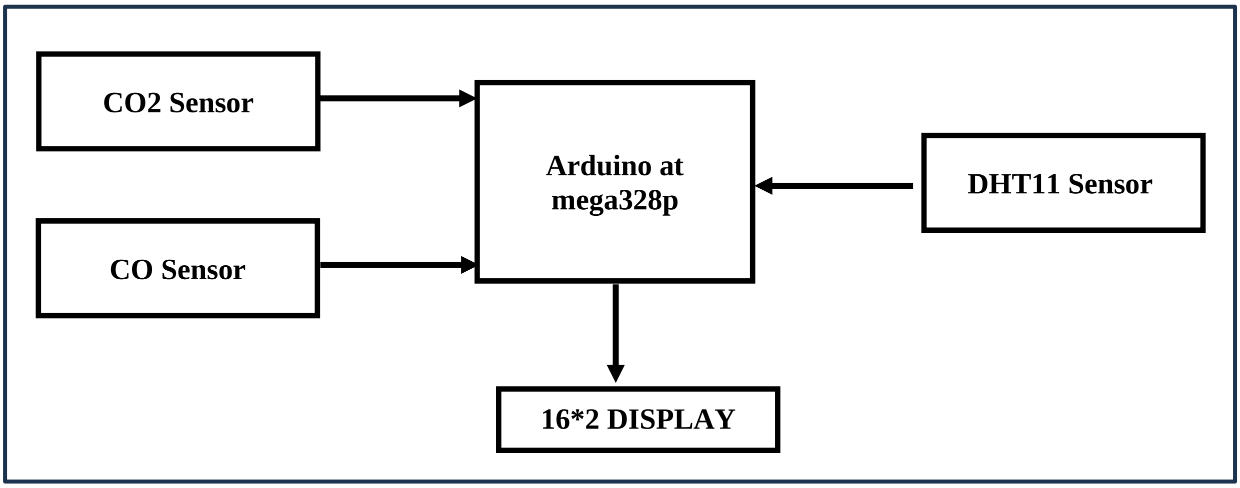


Fig 4.2 Block diagram of Air quality sensing and monitoring

4.3 Sequence Diagram

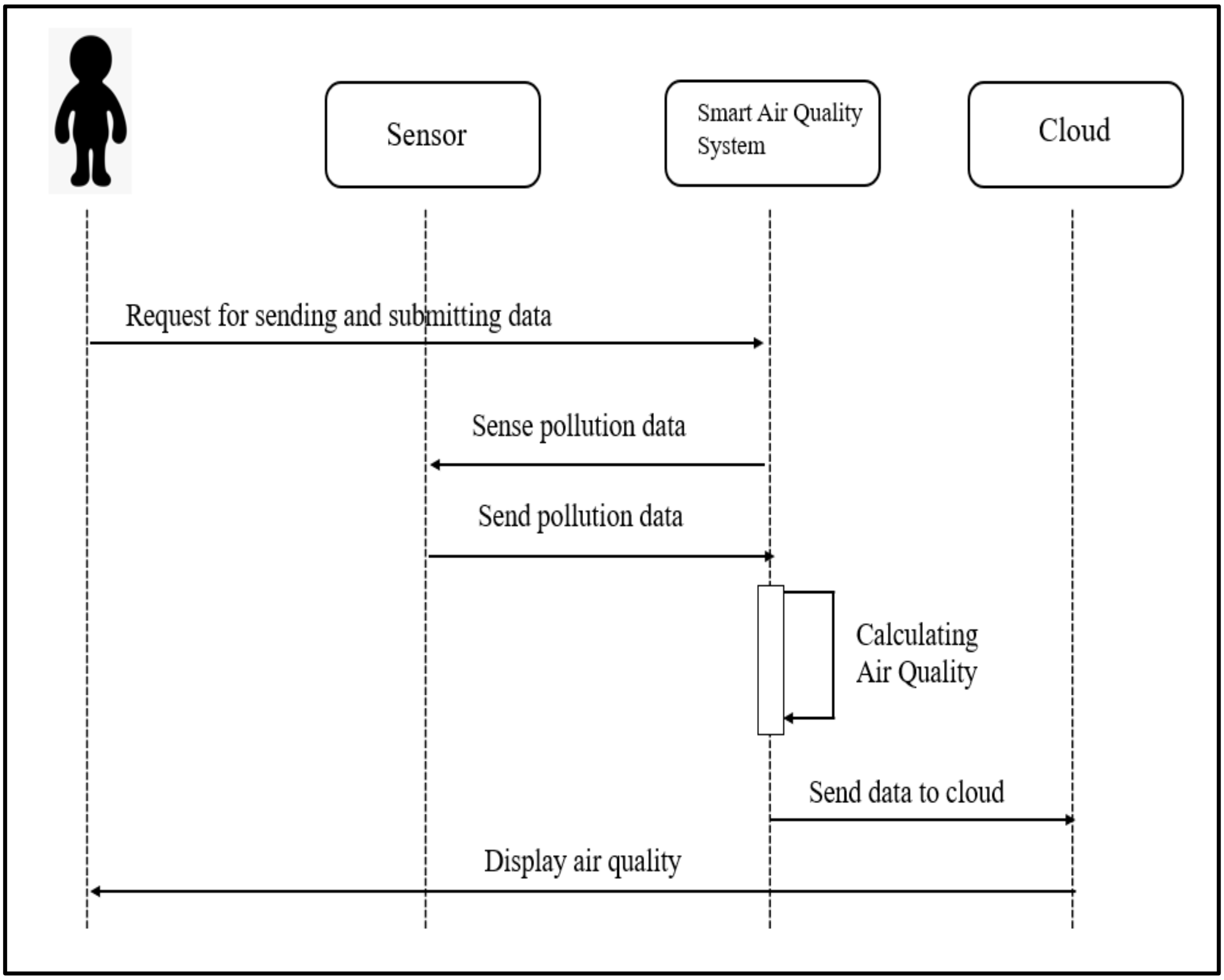


Fig 4.3 Sequence diagram of Air quality sensing and monitoring

CHAPTER 5

SYSTEM IMPLEMENTATION

In this section, the description of the proposed system is provided. This system will monitor the Air Quality over an application using internet and will trigger a notification when the air quality goes down beyond a certain level, means when there are sufficient number of harmful gases are present in the air like CO_2 (carbon dioxide), Temperature and humidity. It will show the air quality in percentage value on the LCD and as well as on mobile application that can be monitored very easily. The system will show temperature and humidity, they are displayed on LCD.

The system is developed with help of sensors, microcontroller, I2C and mobile phone with IoT application. All sensors used in system are connected to Arduino microcontroller. The sensors used in system will sense all gases, and it will give the Pollution level in percentage value. MQ135, MQ2 sensor will give the output in form of voltage levels. If the gas concentration increases output voltage increases and the voltage values are converted it into percentage. According to the model developed four sensors are used that works as input data, to know the concentration levels of gases, humidity and temperature values. LCD and IoT application are the output devices. When the system is powered, the sensors start working and acts like input taker and sends the collected data to Arduino microcontroller. The module sends the collected information to LCD where output is displayed. On LCD the values are displayed in percentage for gases levels, temperature in degrees and humidity in percentage. Arduino microcontroller sends data to IoT application as well. In crafting this sophisticated air quality monitoring system, a meticulous framework has been intricately designed to address the pressing need for continuous assessment of our surrounding environment. At its core, the system endeavors to uphold the well-being of individuals by seamlessly evaluating ambient air quality and transmitting real-time data to a dedicated application accessible via the internet. An indispensable feature of this cutting-edge system is its capability to proactively generate notifications, promptly alerting users the moment air quality dips below predetermined thresholds.

This dynamic approach ensures that individuals remain informed about the ever-changing atmospheric conditions, empowering them to take prompt and informed actions for their well-being. The system's discerning eye spans a spectrum of vital environmental metrics, including the concentration levels of CO_2 (carbon dioxide), temperature, and humidity. By focusing on these key parameters, the system delivers a comprehensive and nuanced understanding of the immediate surroundings.

This multifaceted approach not only caters to health and safety concerns but also extends its utility to various industries, from smart homes and urban planning to industrial facilities, where maintaining optimal environmental conditions is paramount.

The intricate orchestration of this innovation lies in the amalgamation of state-of-the-art sensors, a powerful microcontroller, I2C (Inter-Integrated Circuit) communication, and a mobile phone equipped with an Internet of Things (IoT) application. At the heart of this setup is the versatile Arduino microcontroller, functioning as the central processing unit orchestrating a seamless interaction with all connected sensors. Notably, the chosen sensors, MQ135 and MQ2, prove to be instrumental in gauging gas concentrations, translating them into voltage levels. The dynamic response of these sensors, where increased gas concentrations correlate with rising output voltage, underscores the system's ability to adapt to diverse environmental conditions. To enhance user accessibility, the system employs a sophisticated LCD display, offering immediate insights into a comprehensive array of environmental parameters. Gas levels are intuitively depicted as percentages, temperature is presented in degrees, and humidity is portrayed in percentage form. This real-time data presentation not only empowers users with valuable information at a glance but also fosters a deeper understanding of the intricate interplay between these environmental factors.

Simultaneously, the Arduino microcontroller serves as a dynamic information hub, orchestrating the seamless transmission of vital environmental data to a dedicated IoT application on a mobile device. This application, characterized by its user-friendly interface, not only facilitates remote monitoring but also provides a visually appealing and comprehensive visualization of air quality metrics. This integration, spanning sensors, microcontroller, I2C communication, and IoT technology, positions the air quality monitoring system as a holistic solution.

CHAPTER 6

RESULTS AND DISCUSSION

The air quality sensing and monitoring system utilizing MQ2 CO & CO2 Sensor, DHT11 sensor, Node MCU, Arduino Uno, ATmega328P, and PCB, coupled with integration to the Thing-Speak server and email notification, yielded insightful results and conclusions.

Through extensive data collection and analysis, the system provided real-time monitoring of crucial air quality parameters, including carbon monoxide (CO), carbon dioxide (CO2), and temperature-humidity. This enabled the identification of fluctuations and trends in indoor or outdoor air quality, facilitating proactive measures to mitigate potential health risks or environmental concerns.

The MQ2 CO & CO2 Sensor demonstrated reliable performance in detecting harmful gases such as CO and CO2, with sensitivity and accuracy suitable for various applications. Its integration with Node MCU and Arduino Uno facilitated seamless data acquisition and transmission to the ThingSpeak server, ensuring continuous monitoring and accessibility of air quality data from remote locations.

Additionally, the inclusion of the DHT11 sensor provided supplementary data on temperature and humidity levels, enhancing the comprehensiveness of the monitoring system. This holistic approach enabled a more thorough understanding of environmental conditions, contributing to informed decision-making and intervention strategies.

The utilization of ATmega328P microcontroller and PCB design optimized the system's efficiency and scalability, ensuring stable operation and streamlined integration of multiple sensors and components. Furthermore, the integration with ThingSpeak server enabled data visualization, analysis, and historical tracking, empowering users to monitor long-term trends and patterns in air quality parameters.

Moreover, the implementation of email notification alerts added an extra layer of functionality, allowing users to receive timely notifications in case of critical air quality deviations or anomalies. This feature enhanced the system's responsiveness and usability, enabling prompt actions to address emerging issues or emergencies.

Through extensive data collection and analysis, the system provided real-time monitoring of crucial air quality parameters, including carbon monoxide (CO), carbon dioxide (CO2), and temperature-humidity. This enabled the identification of fluctuations and trends in indoor or outdoor air quality, facilitating proactive measures to mitigate potential health risks or environmental concerns. Additionally, the system's ability to store and process large datasets allowed for more detailed analysis and long-term studies, potentially uncovering patterns that might not be immediately apparent in short-term observations.

In conclusion, the air quality sensing and monitoring system employing MQ2 CO & CO2 Sensor, DHT11 sensor, Node MCU, Arduino Uno, ATmega328P, PCB, ThingSpeak server integration, and email notification functionality proved to be an effective solution for real-time air quality monitoring. Its robust performance, comprehensive data acquisition capabilities, and user-friendly features make it a valuable tool for various applications, ranging from indoor air quality management to environmental monitoring and public health initiatives. Continued refinement and optimization of the system could further enhance its functionality and applicability in diverse settings, contributing to a healthier and safer environment for all.

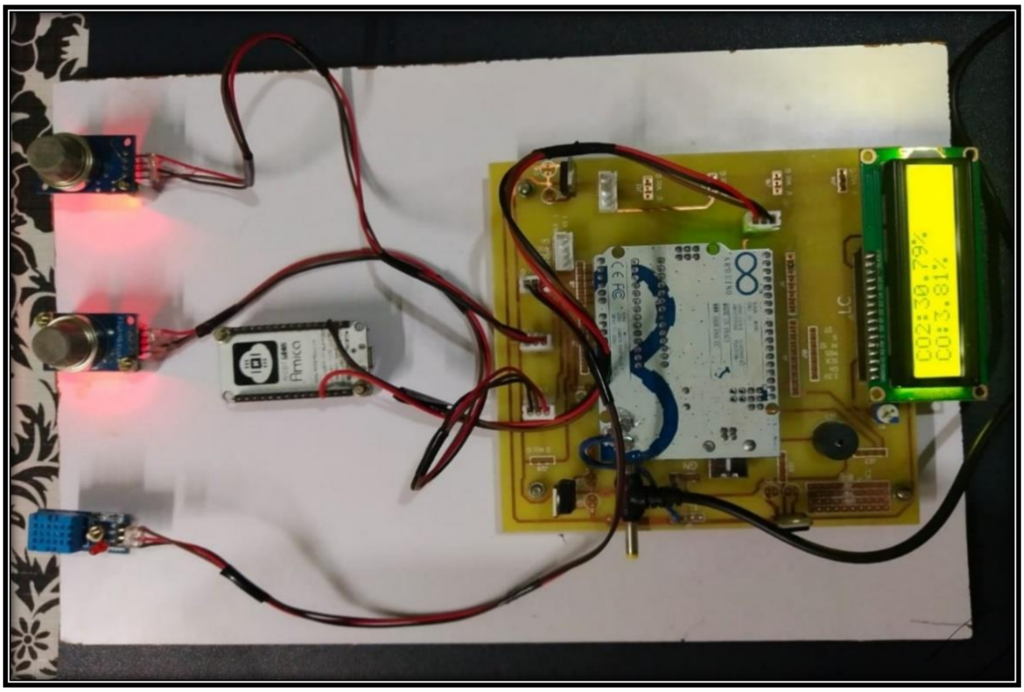


Fig 6.1 working model of the project

Fig 6.2 Final Prototype of the project

ThingSpeak cloud server

ThingSpeak serves as a centralized platform for harnessing the potential of IoT (Internet of Things) devices. Here's a detailed breakdown of its functionalities:

1. Data Aggregation: ThingSpeak aggregates data from various IoT devices. These devices could be anything from temperature sensors in a smart home to GPS trackers in a fleet management system. The platform collects this data, allowing for centralized access and management.

2. Real-time Visualization: Once the data is collected, ThingSpeak provides tools to visualize it in real-time. This could include graphs, charts, maps, or other graphical representations. These visualizations offer immediate insights into the data stream, making it easier to understand trends, anomalies, and patterns as they occur.

3. Data Analysis: Beyond just visualizing the data, ThingSpeak enables deeper analysis. Users can apply analytical tools and algorithms to the data to uncover insights and correlations. For example, they might identify correlations between environmental conditions and equipment performance, leading to more informed decision-making.

4. Alerting Mechanisms: ThingSpeak allows users to set up alerts based on specific conditions or patterns within the data stream. For instance, if the temperature in a server room exceeds a certain threshold, an alert can be triggered, prompting immediate action to prevent equipment damage or downtime. These alerts help in proactive monitoring and management of IoT systems.

5. Optimization of IoT Systems: By providing a comprehensive set of tools for data management, visualization, analysis, and alerting, ThingSpeak facilitates the optimization of IoT systems. Users can identify inefficiencies, improve performance, and enhance decision-making processes based on real-time insights gleaned from their IoT data.

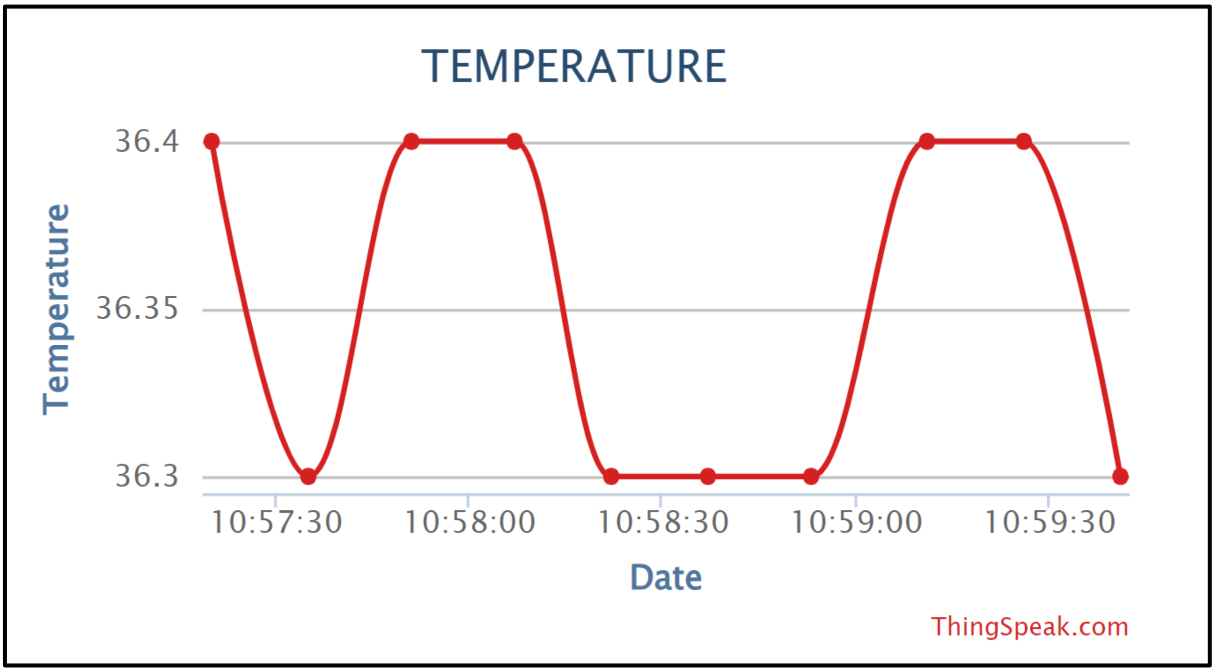


Fig 6.3 Temperature Graph real-time

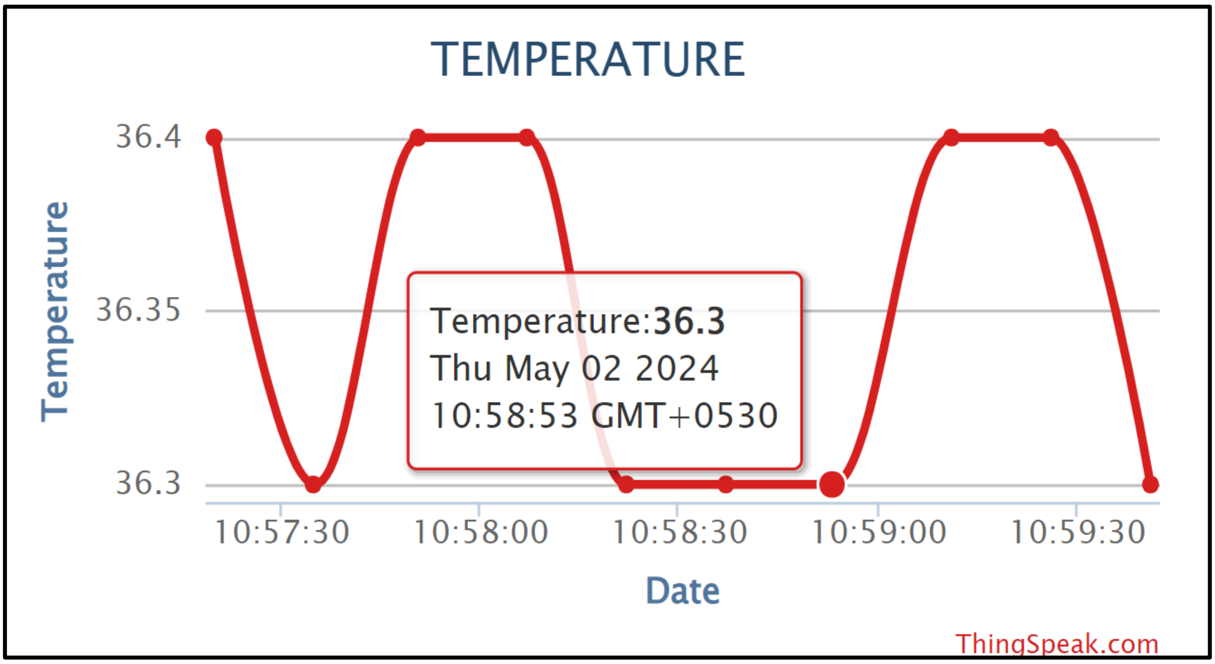


Fig 6.4 Temperature Graph real-time with information

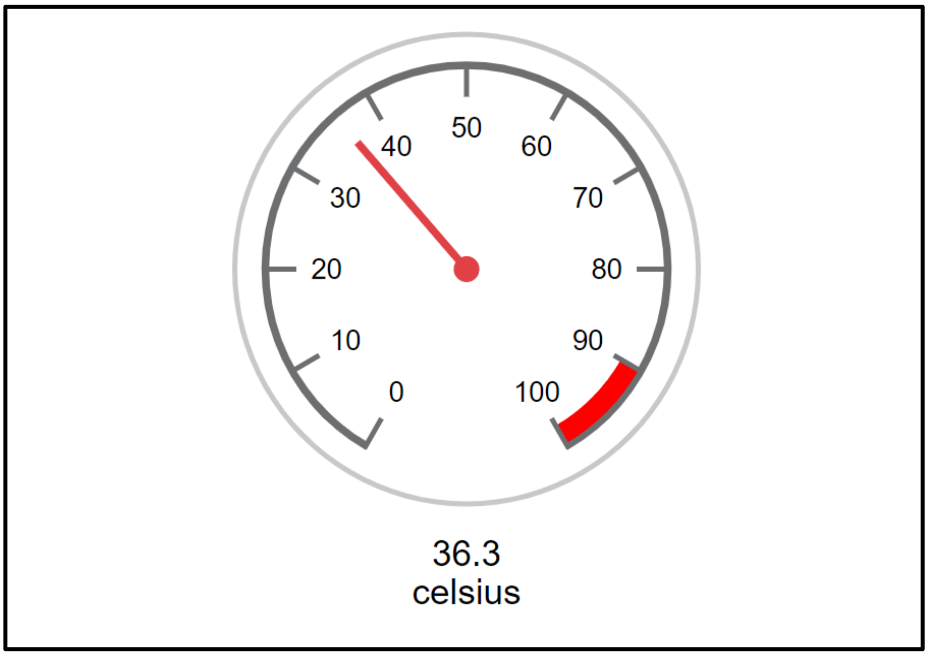


Fig 6.5 Temperature Gauge for better understand

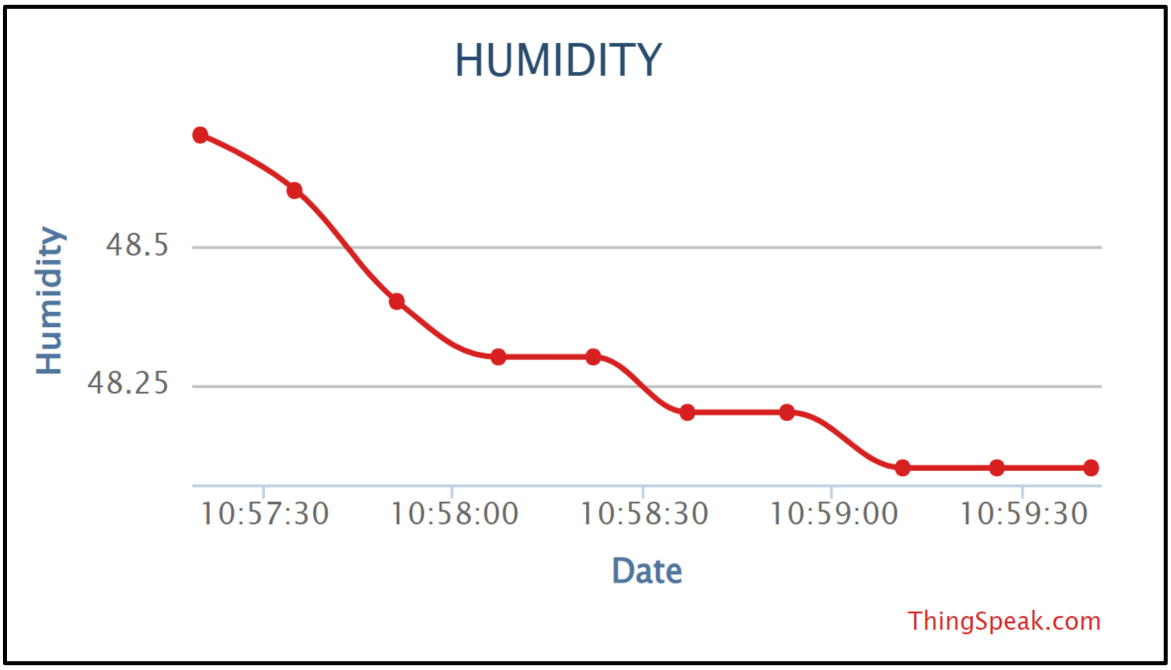


Fig 6.6 Humidity Graph real-time

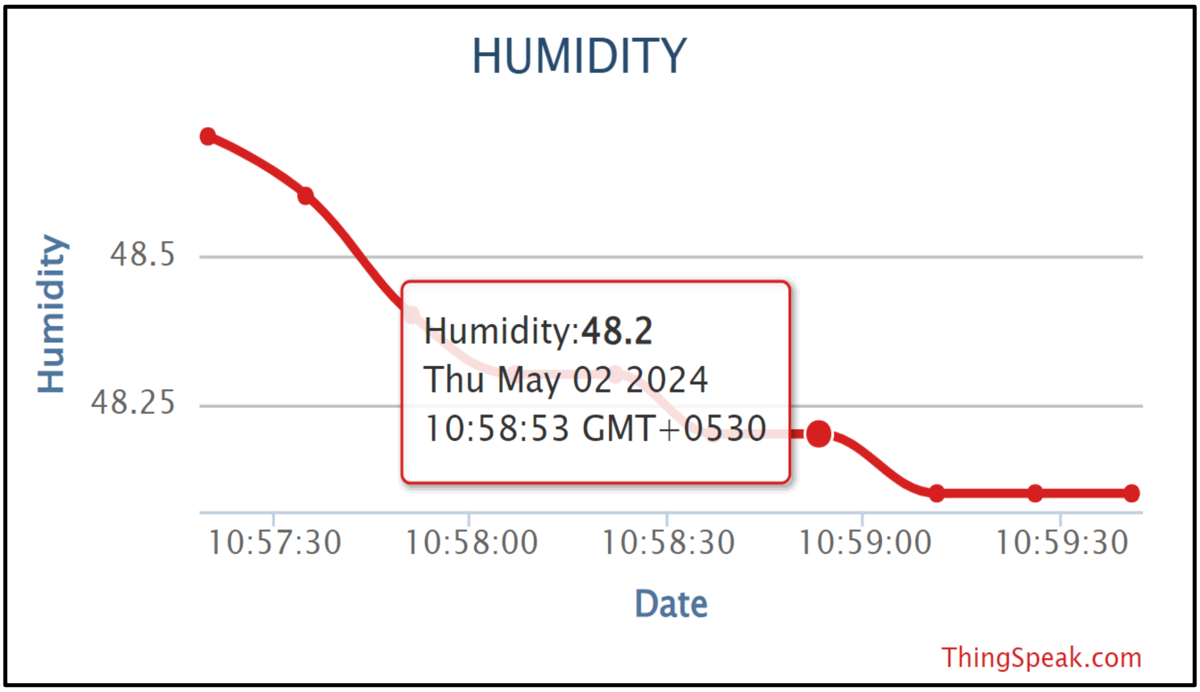


Fig 6.7 Humidity Graph real-time with information

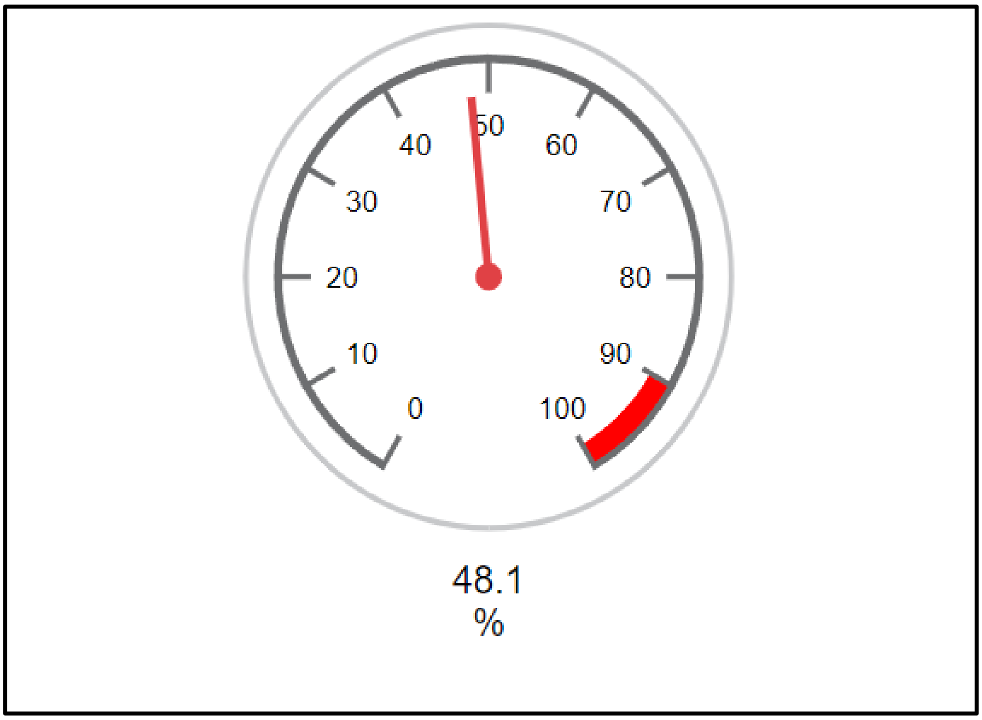


Fig 6.8 Humidity Gauge with information

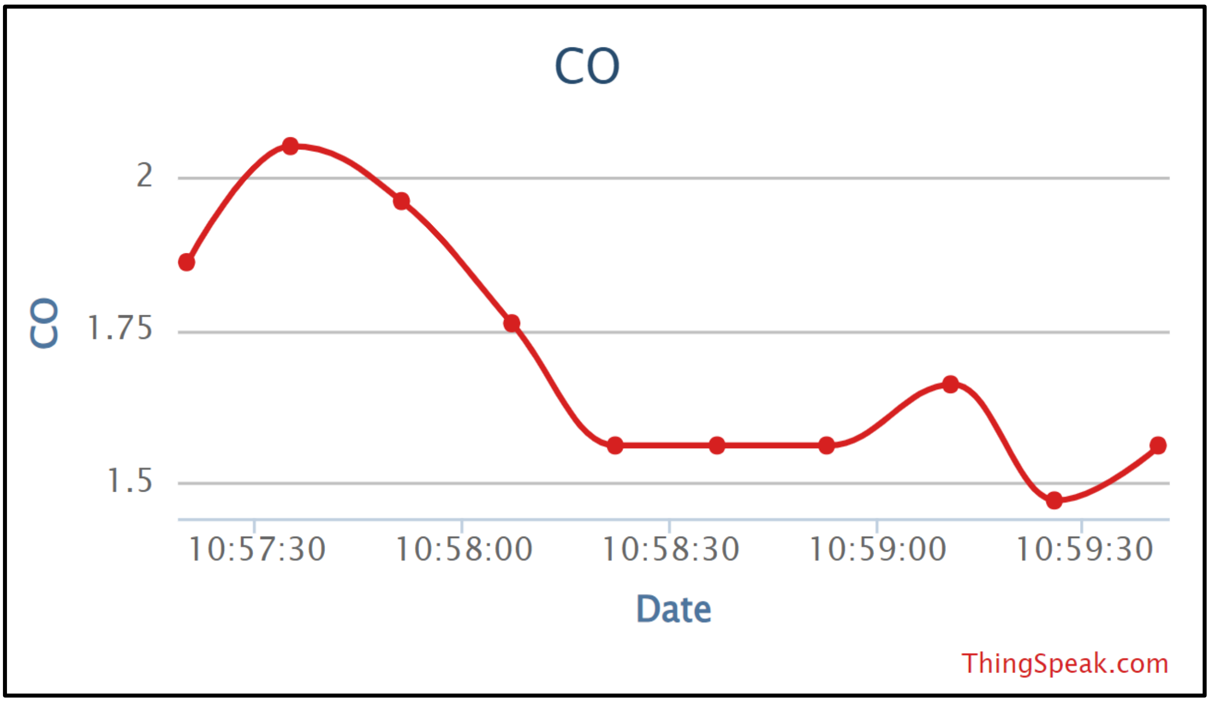


Fig 6.9 Carbon monoxide graph real-time

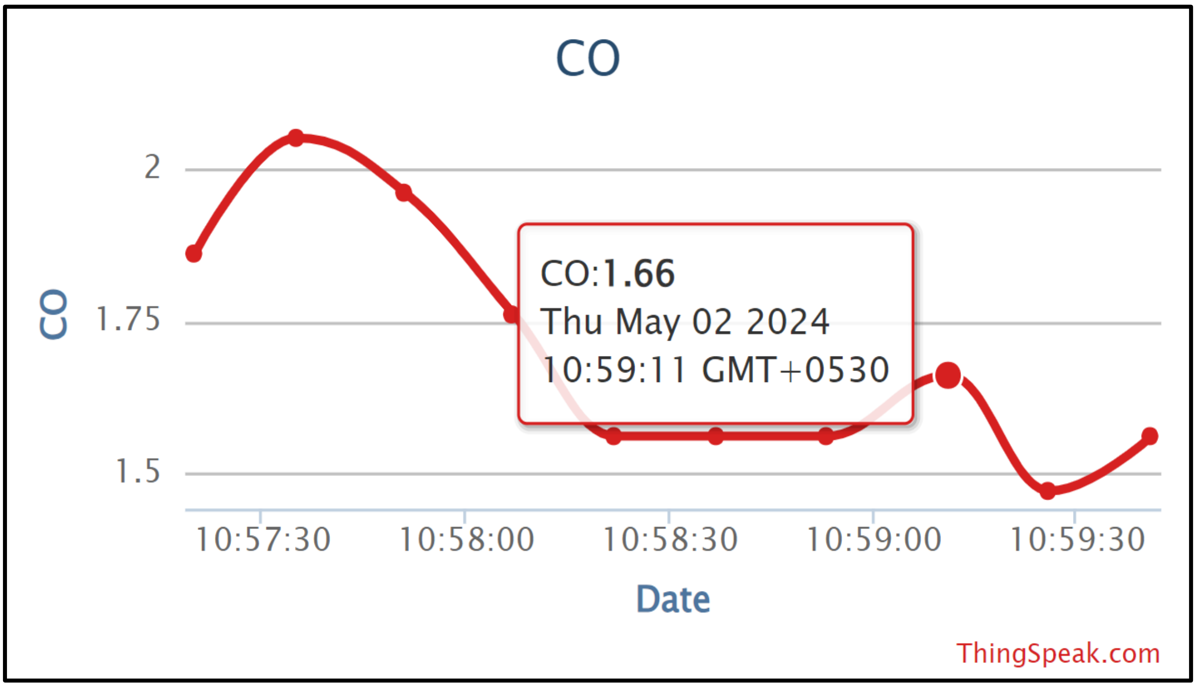


Fig 6.10 Carbon monoxide graph real-time with information

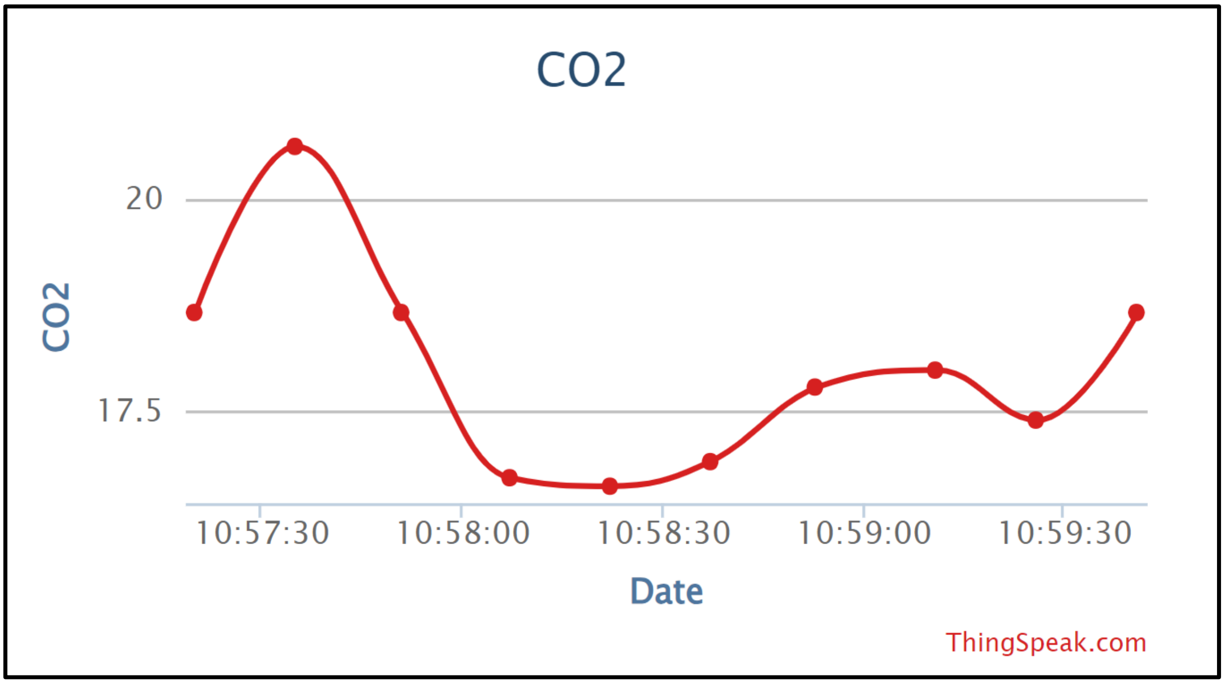


Fig 6.11 Carbon dioxide graph with real-time

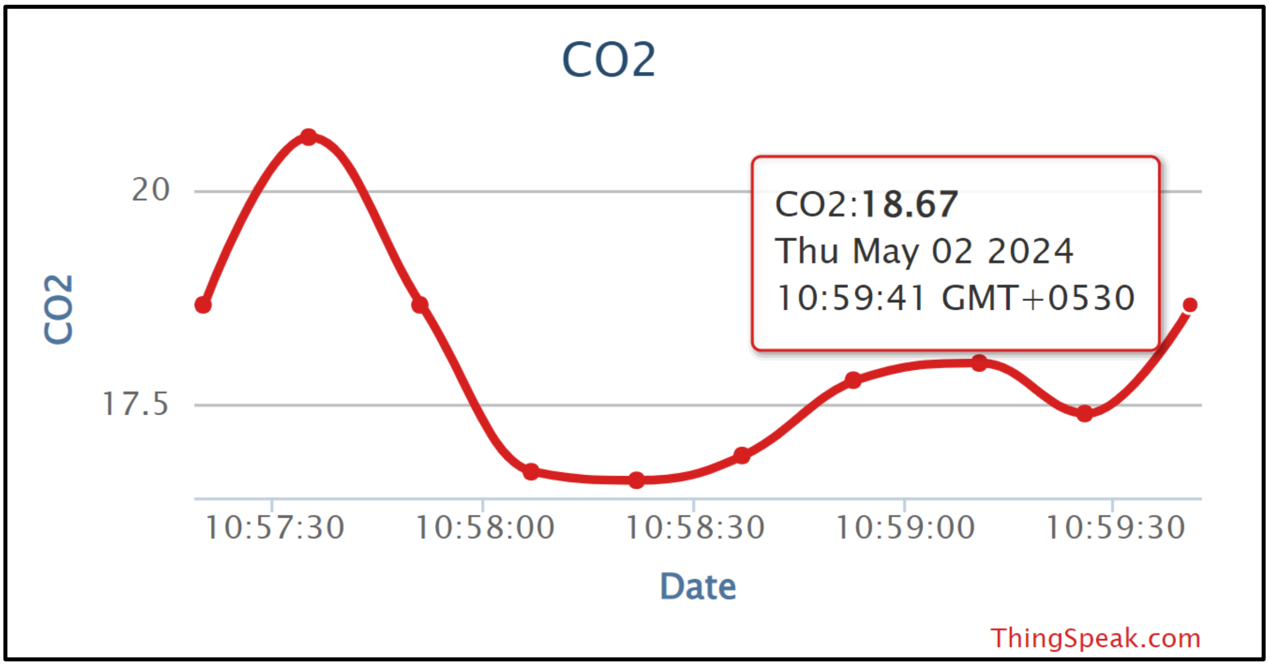


Fig 6.12 Carbon dioxide graph real-time with information

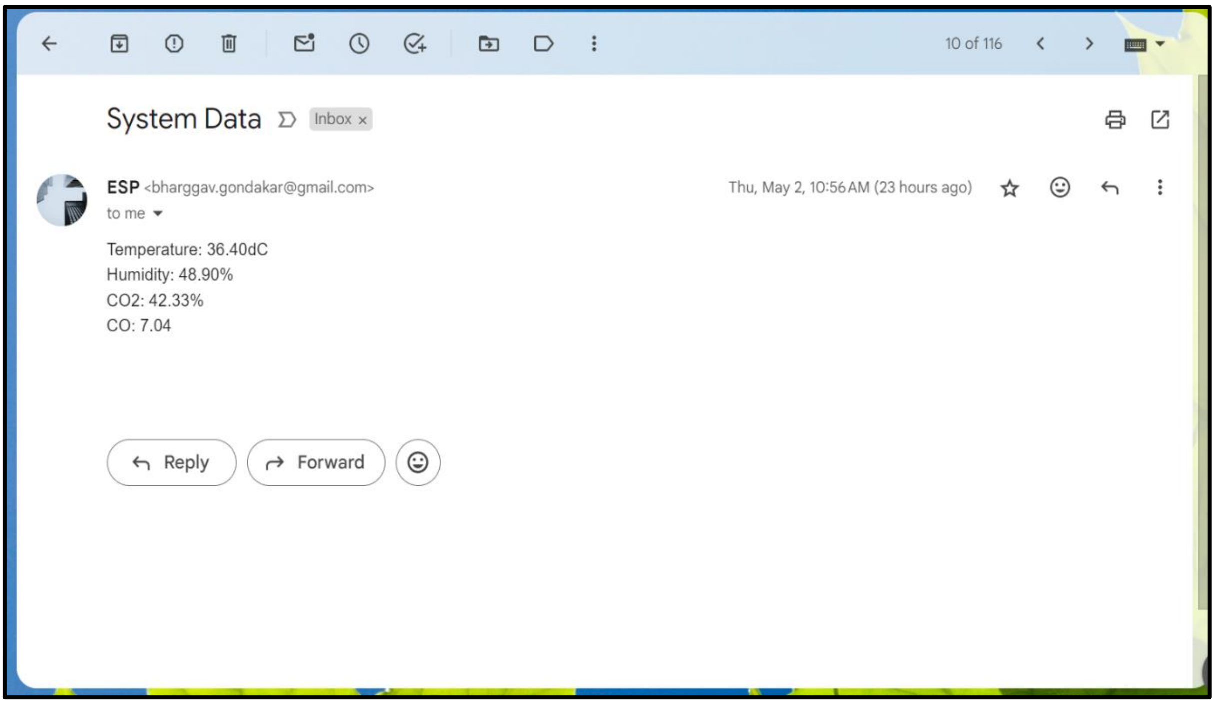
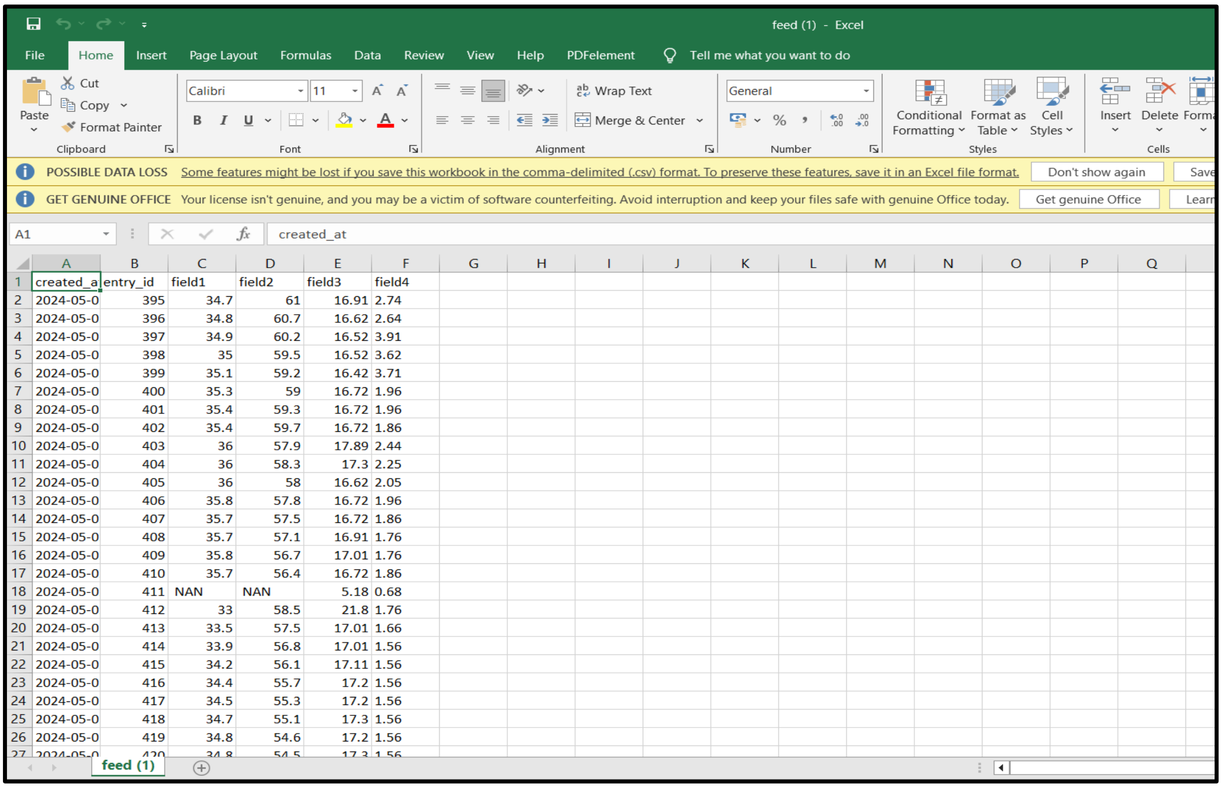


Fig 6.13 Parameter's alert message to given email



	A	B	C	D	E	F
1	created_a	entry_id	field1	field2	field3	field4
2	2024-05-0	395	34.7	61	16.91	2.74
3	2024-05-0	396	34.8	60.7	16.62	2.64
4	2024-05-0	397	34.9	60.2	16.52	3.91
5	2024-05-0	398	35	59.5	16.52	3.62
6	2024-05-0	399	35.1	59.2	16.42	3.71
7	2024-05-0	400	35.3	59	16.72	1.96
8	2024-05-0	401	35.4	59.3	16.72	1.96
9	2024-05-0	402	35.4	59.7	16.72	1.86
10	2024-05-0	403	36	57.9	17.89	2.44
11	2024-05-0	404	36	58.3	17.3	2.25
12	2024-05-0	405	36	58	16.62	2.05
13	2024-05-0	406	35.8	57.8	16.72	1.96
14	2024-05-0	407	35.7	57.5	16.72	1.86
15	2024-05-0	408	35.7	57.1	16.91	1.76
16	2024-05-0	409	35.8	56.7	17.01	1.76
17	2024-05-0	410	35.7	56.4	16.72	1.86
18	2024-05-0	411	NAN	NAN	5.18	0.68
19	2024-05-0	412	33	58.5	21.8	1.76
20	2024-05-0	413	33.5	57.5	17.01	1.66
21	2024-05-0	414	33.9	56.8	17.01	1.56
22	2024-05-0	415	34.2	56.1	17.11	1.56
23	2024-05-0	416	34.4	55.7	17.2	1.56
24	2024-05-0	417	34.5	55.3	17.2	1.56
25	2024-05-0	418	34.7	55.1	17.3	1.56
26	2024-05-0	419	34.8	54.6	17.2	1.56
27	2024-05-0	420	34.8	54.5	17.3	1.56

Fig 6.14 CSV Data extract for analysis

CHAPTER 7

CONCLUSION AND SCOPE OF FUTURE WORK

In this project IoT based on measurement and display of Air Quality Index (AQI), Humidity and Temperature of the atmosphere have been performed. From the information obtained from the project, it is possible to calculate Air Quality in PPM. The disadvantage of the MQ135 sensor is that specifically it can’t tell the Carbon Monoxide or Carbon Dioxide level in the atmosphere, but the advantage of MQ135 is that it is able to detect smoke, CO, CO2, etc. harmful gases. After performing several experiments, it can be easily concluded that the setup is able to measure the air quality in ppm, the temperature in Celsius and humidity in percentage with considerable accuracy. The results obtained from the experiments are verified through Google data. Since it’s an IOT-based project, it will require a stable internet connection for uploading the data to the Think Speak cloud. Therefore, it is possible to conclude that the designed prototype can be utilized for air quality, humidity and temperature of the surrounding atmosphere successfully.

The future of air quality sensing and monitoring holds promise for advancements in both technology and application. Innovations may include the development of more compact and affordable sensor arrays capable of real-time data collection across diverse environments. Integration with AI and machine learning algorithms could enable predictive modeling of air quality trends, empowering early intervention strategies. Furthermore, the expansion of IoT networks and cloud-based platforms may facilitate seamless data sharing and analysis, fostering collaboration among researchers, policymakers, and the public. In this evolving landscape, interdisciplinary approaches combining expertise in environmental science, engineering, and data analytics will be crucial for addressing emerging challenges and maximizing the societal impact of air quality monitoring initiatives.

Hardware components information: -

ESP 32

ESP32 is a low-cost System on Chip (SoC) Microcontroller from Espressif Systems, the developers of the famous ESP8266 SoC. It is a successor to ESP8266 SoC and comes in both single-core and dual-core variations of the Tensilica's 32-bit Xtensa LX6 Microprocessor with integrated Wi-Fi and Bluetooth. The good thing about ESP32, like ESP8266 is its integrated RF components like Power Amplifier, Low-Noise Receive Amplifier, Antenna Switch, Filters and RF Balun.

LCD display

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical, easily programmable, have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

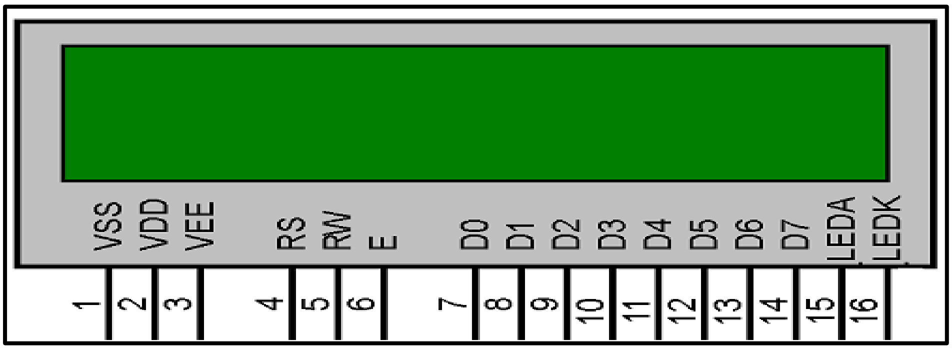


Fig 7.1 Pin diagram of an LCD 16x2

Table 7.1 Pin details

7	D0 (Data Pin 0)	These 8 Pins are used to sending commands or data to the LCD. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller data pin 0 to 3. And in 8-wire mode, 8-pins are connected to microcontroller data pin 0 to 7.
8	D1 (Data Pin 1)	
9	D2 (Data Pin 2)	
10	D3 (Data Pin 3)	
11	D4 (Data Pin 4)	
12	D5 (Data Pin 5)	
13	D6 (Data Pin 6)	
14	D7 (Data Pin 7)	
15	LED + (+5V)	This is the positive terminal of the backlight LED of the display. It's connected to +5V to turn on the backlight LED.
16	LED – (Ground)	This is the negative terminal of the backlight LED of the display. It's connected to the ground to turn on the backlight LED.

MQ 2 CO Sensor

MQ-2 Sensor A carbon Dioxide analyzer or CO analyzer is a device that detects the presence of the carbon monoxide gas in order to prevent carbon monoxide poisoning. The circuit setup consists of analyzer head connected to an amplifying unit. A number of supporting resistances are used to avoid voltage drop across the circuit. Resistance value of MQ-2 is difference to various kinds and various concentration gases. So, when using these components, sensitivity adjustment is necessary. It is recommended that calibrating the detector for 200ppm CO in air and using Load resistance of about 10KΩ (5KΩ to 47 KΩ) increases circuit efficiency.

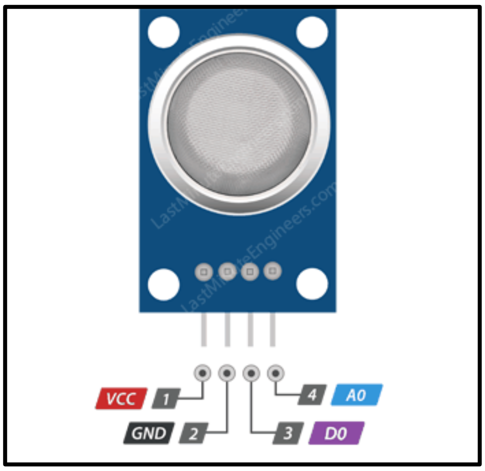


Fig 7.2 Pin information

- ✓ VCC: Supplies power for the module. You can connect it to 5V output from your Arduino.
- ✓ GND: Is the Ground Pin and needs to be connected to GND pin on the Arduino.
- ✓ D0: Provides a digital representation of the presence of combustible gases.
- ✓ A0: Provides analog output voltage in proportional to the concentration of smoke/gas.

Table 7.2 Pin description

Operating voltage	**5V**
Load resistance	**20 KΩ**
Heater resistance	**33Ω ± 5%**
Heating consumption	**<800mw**
Sensing Resistance	**10 KΩ – 60 KΩ**
Concentration Scope	**200 – 10000ppm**

DHT11 Sensor

This DHT22 is a temperature & a humidity sensor with a digital signal output. It provides high stability and reliability. It consists of a Negative temperature coefficient temperature measuring component and a resistive type humidity measurement component. It can be connected to a microcontroller and offers quick, anti-interference ability and cost-effectiveness.

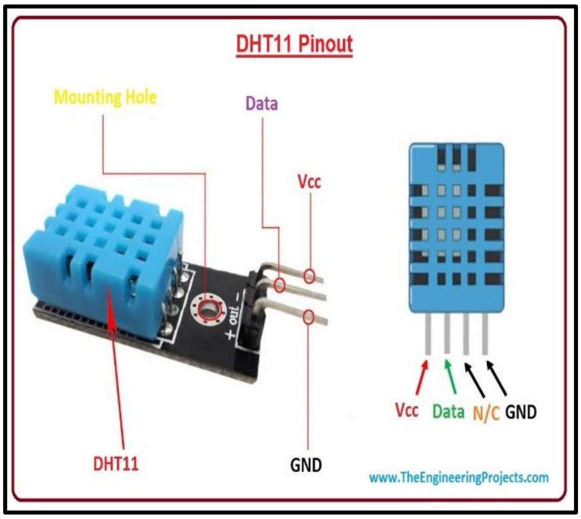


Fig 7.3 DHT11 Pin Information

Table 7.3 Pin Details

Pin#	Type	Parameters
Pin#1	Vcc	This pin is used for input purpose at this pin we apply 3.3 v to 5v input supply.
Pin#2	Data	By this pin we get output of temperature and humidity values, by serial transmission protocol.
Pin#3	N/C	Not Connected.
Pin#4	Ground	This pin is used for Ground (Connected to 0V or GND).

Software information: -

Arduino software

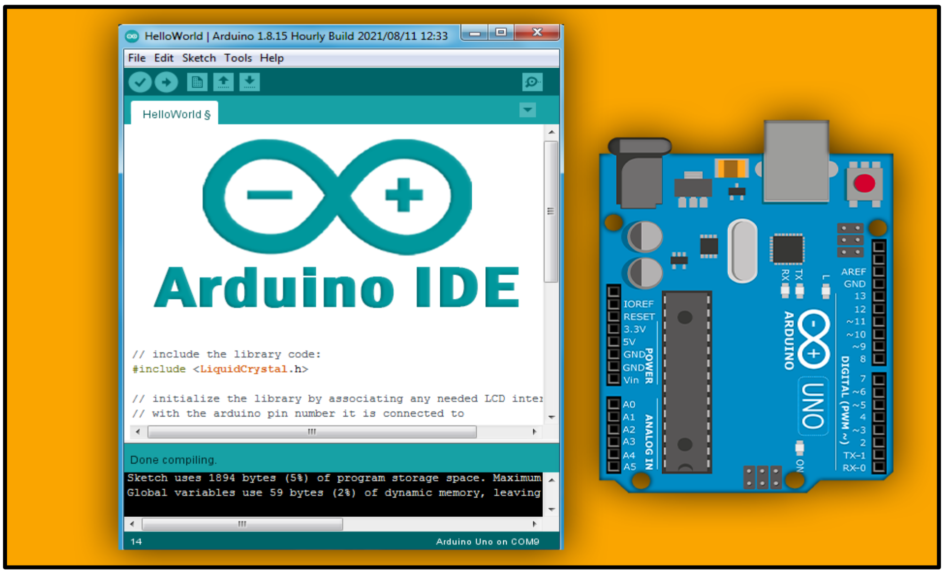


Fig 7.4 Arduino UNO software interface and component

Arduino IDE

The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as **Windows, Mac OS X, and Linux**. It supports the programming languages C and C++. Here, IDE stands for **Integrated Development Environment**. The program or code written in the Arduino IDE is often called as sketching. We need to connect the Genuino and Arduino board with the IDE to upload the sketch written in the Arduino IDE software. The sketch is saved with the extension '.ino.'

Arduino code Upload

The Upload button compiles and runs our code written on the screen. It further uploads the code to the connected board. Before uploading the sketch, we need to make sure that the correct board and ports are selected. We also need a USB connection to connect the board and the computer. Once all the above measures are done, click on the Upload button present on the toolbar. The latest Arduino boards can be reset automatically before beginning with Upload. In the older boards, we need to press the Reset button present on it. As soon as the uploading is done successfully, we can notice the blink of the Tx and Rx LED. If the uploading is failed, it will display the message in the error window.

Embedded C Language

A general term for such subsets is "Embedded C" because they apply to programming embedded controllers. The language in which Arduino is programmed is a subset of C and it includes only those features of standard C that are supported by the Arduino IDE.
This does not mean that Arduino C lags anywhere because it is a subset of C. Most of the missing features of standard C can be easily worked around. Rather, Arduino C is a hybrid of C and C++, meaning it is functional and object-oriented.

1. Digital Input: This may be received in digital LOW or HIGH from other devices. These will be TTL logic levels or voltages converted to TTL logic levels before being applied.
2. Digital Output: This may be output that's digital LOW or HIGH compared to other devices. Again, the output will be TTL logic levels.
3. Analog Input: It may "sense" analog voltage from other devices. The sensed voltage is converted to a digital value using a built-in, analog-to-digital converter.
4. Analog Output: It may output analog voltage to other devices. This analog output is not analog voltage but a PWM signal that approximates analog voltage levels.
5. Serial Communication: It may transmit, receive, or transceiver data with other devices in serial, according to a standard serial data protocol such as UART, USART, I2C, SPI, microwire, 1-wire, and CAN, etc. The serial communication with other devices can be peer-to-peer (UART/USART), half-duplex (I2C), or full-duplex (SPI).

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47th series of Student Project Programme (SPP): 2023-24

List of Student Project Proposals Approved for Sponsorship

94. K.L.S. VISHWANATHRAO DESHPANDE INSTITUTE OF TECHNOLOGY, HALIYAL, UTTARA KANNADA

Sl. No.	PROPOSAL REFERENCE NO.	PROJECT TITLE	COURSE	BRANCH	NAME OF THE GUIDE(S)	NAME OF THE STUDENT(S)	AMOUNT SANCTIONED (Rs.)
775.	47S_BE_4146	TREATMENT OF GROUND WATER CONTAMINATION USING GRAPHENE OXIDE OF KARWAR REGION	B.E.	CIVIL ENGINEERING	Prof. SEEMA R. BASARIKATTI	Mr. AMAN LOKESH HEGDE Ms. BISHTAKKA TARIHAL Mr. PRASHANT NARAGUND Mr. SANDEEP BHAJANTRI	3,500.00
776.	47S_BE_3822	AIR QUALITY SENSING AND MONITORING	B.E.	COMPUTER SCIENCE AND ENGINEERING	Prof. POORNIMA RAIKAR Dr. VENKATESH SHANKAR	Mr. SAVIO REBELLO Mr. JONATHAN W. DAVID Mr. BHARGGAV GONDAKAR Ms. RAKSHITA R. DEVARADDI	4,500.00
777.	47S_BE_4452	SMART MEDICATION DISPENSER AND REMINDER USING EMBEDDED SYSTEM	B.E.	ELECTRONICS AND COMMUNICATION ENGINEERING	Prof. NIKHIL A. KULKARNI	Mr. FAIROZ RAMAPUR Mr. CHARAN C. SHANBOG Mr. DHEERAJ V. KULKARNI Mr. FAYAZANWAR I. JAKATI	5,500.00
778.	47S_BE_0470	GREEN METAL MATRIX COMPOSITES: REPURPOSING DEBRIS FOR ENGINEERING PURPOSES	B.E.	MECHANICAL ENGINEERING	Dr. GURURAJ HATTI	Mr. AKSHAY KITTUR Mr. SHASHANK S. YANKANCHI Mr. OMKAR P. NARVEKAR	5,500.00
779.	47S_BE_1562	PERFORMANCE EVALUATION OF PORTABLE DOMESTIC SOLAR VEGETABLE DRYER	B.E.	MECHANICAL ENGINEERING	Dr. SHANKAR BADIGER	Mr. MANJUNATH P. MORE Mr. VISHWA GOUDA Mr. PRAVESH SAVANT Mr. GIRISH PATIL	5,500.00

KSCST: 47th Series of Student Project Programme (SPP): Sponsored Projects   Page **190** of **387**

Fig 7.5 Selected for KSCST 2023-2024

---------- Forwarded message ---------
From: **International Journal of Science and Research Archive** <editor@ijsra.net>
Date: Mon, May 20, 2024 at 8:07 PM
Subject: Your Manuscript (IJSRA-2024-0893) is accepted for further publication process
To: <vss@klsvdit.edu.in>

Dear Author,
Greetings for the day...

We are pleased to inform you that your manuscript **(Manuscript ref. no. IJSRA-2024-0893)** entitled ***"Air Quality Sensing and Monitoring"*** is accepted for further publication process after editorial review.

We already have sent a separate e-mail regarding this with details for submission of required documents as well as Payment of article processing charges. Please check it in your inbox or Spam folder and do the needful.

If you need more information, feel free to contact us.

With Best Regards,
Managing Editor
International Journal of Science and Research Archive (IJSRA)

Fig 7.6 Letter of acceptance from IJSRA (International Journal of Science and Research Archive)

International Journal of Novel Research and Development(IJNRD)
An International Scholarly Open Access Journal, Peer-Reviewed, Refereed Journal Impact Factor 8.76 Calculate by Google Scholar and Semantic Scholar | AI-Powered Research Tool, Multidisciplinary, Monthly, Multilanguage Journal Indexing in All Major Database & Metadata, Citation Generator, Peer-Reviewed, Refereed, Indexed, automatic Citation Open Access Journal

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Dear Savio Rebello,

Your manuscript with Registration ID: IJNRD221851 has been **Accepted** for publication in the International Journal of Novel Research and Development (www.ijnrd.org). Track Your Paper Link Track Your Paper https://www.ijnrd.org/track.php?r_id=221851 Your Review Report is as follows:

An International Scholarly Open Access Journal, Peer-Reviewed, Refereed Journal Impact Factor 8.76 Review Results

Registration ID	IJNRD221851
Email ID	saviorebello9481@gmail.com
Paper Title	Air Quality Sensing and Monitoring
Review Status	Accepted
Impact Factor & Licence:	Open Access, Peer-Reviewed, Refereed, Indexing,ISSN Approved,DOI and Creative Common Approved & 8.76 Calculated by Google Scholar
Overall Assessment	Overall Assessment=94 % (Point Given Out of 100) Reviewer Criteria (Point Given out of 100) Continuity = 97 , Text structure = 98 , References= 97 , Understanding and Illustrations= 78 , Explanatory power= 88 , Detailing= 86 , Relevance and practical advice= 91.
Unique Contents	94 %
Comments	Paper Accepted Complete Payment and documents Process. Complete Phase 2 Payment and Phase 3 Documents Process so within 1 to 2 day it will publish

Fig 7.7 Letter of acceptance from IJNRD (International Journal of Novel Research and Development)

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3. IoT based Pollution Monitoring and Controlling using Arduino Christina Jane* School of ECE Mar Ephraem College of Engineering and Technology Marthandam, India. F.A. Princi Rani School of ECE Mar Ephraem College of Engineering and Technology Marthandam, India. S. Reethu School of ECE Mar Ephraem College of Engineering and Technology Marthandam, India. R. Benschwartz School of ECE Mar Ephraem College of Engineering and Technology Marthandam, India (IEEE- 2021)

4. An Integrated Sensing Systems for Real-Time Indoor Air Quality Monitoring Jung-Yoon Kim, Chao-Hsien Chu, and Sang-Moon Shin (IEEE- 2019)

5. Real Time Localized Air Quality Monitoring and Prediction Through Mobile and Fixed IoT Sensing Network DAN ZHANG AND SIMON S. WOO (IEEE- 2020)

Appendix A:

Software Requirements

1) Arduino Software

2) Embedded C Language

3) Thing-Speak Server

Appendix B:

Hardware Requirements

1) MQ 2 CO Sensor

2) ESP 32 Controller

3) 16x2 LCD

4) Buzzer

5) Arduino at mega328p

6) DHT 11 Sensor

7) Node MCU ESP8266