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# ADVANCEMENTS IN AIR QUALITY MONITORINGTECHNIQUES & TECHNOLOGIES

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## ABSTRACT
This presentation discusses advances in air quality monitoring techniques and technologies that aim to address the global problem of air pollution. The integration of several sensors, including the Sensitive Gas MQ-Series gas sensors, is the main area of interest for this study. These sensors can be used to identify a variety of pollutants, such as LPG (MQ-2), Methane(MQ-4), hydrogen (MQ-6), hydrogen gas (MQ-8)and nitrogen dioxide (MQ-135). An analysis, comprehension, and projection of the vast quantity of data collected by Raspberry Pi isstored in cloud. These technologies will be used by the proposedair monitoring system to provide real-time insights into air qualitylevels and enable quick responses, protecting public health and minimizing pollution. Liquid Crystal Display (LCD) and graphical representation are used to display the results. The cloud(Thingspeak) displays and makes available the amounts of the above specified gases. The range of gases is also shown in the display's second row.

**Keywords**—
Raspberry pi, LCD ,Mingin Qilai (MQ-2), Mingin Qilai (MQ-4), Mingin Qilai (MQ-6), Mingin Qilai (MQ-8), Mingin Qilai (MQ-135), Thingspeak.

## I. INTRODUCTION
In today's world, where concerns about pollution loom large, ensuring clean air is paramount for our well-being. A smart system designed to monitor air quality more effectively. Our aim is simple yet significant to combat air pollution with accessible and innovative technology. At the heart of our project are specialized sensors, a clever Raspberry Pi computer, and user-friendly tools like LCD screens and cloud storage. Together, these components form a cohesive system that provides comprehensive insights into air quality, enabling prompt action when needed. [1].

The sensors act as vigilant guardians, detecting harmfulsubstances like Carbon Monoxide, Nitrogen dioxide, andMethane, Hydrogen, LPG in the air. These sensors worktirelessly to ensure our environment remains safe and healthy.Driving the intelligence of our system is the Raspberry Pi Pico W, a compact yet powerful computer known for its versatility.Utilizing the user-friendly MicroPython programminglanguage, the Raspberry Pi swiftly processes data from oursensors, delivering real-time updates on air quality metrics. [2] To visualize the results, the LCD screen and the cloud. The LCD screen provides immediate feedback with easy-to-understand graphics, allowing users to assess air quality at aglance. Meanwhile, the cloud platform facilitated by Thingspeak offers detailed data and graphs over time,facilitating a deeper understanding of air quality trends andfostering collaboration in pollution mitigation efforts. [4, 7] To enhance safety measures, incorporated a beep alarm.

This feature serves as an early warning system, alerting users when pollutant levels reach concerning thresholds, enabling swiftaction to protect public health. [6]

The project represents a significant leap forward in the fight against air pollution. By combining smart sensors, computing power, and intuitive interfaces, equipping individuals and communities with the tools they need to monitor air quality effectively and drive positive change. [3]

Monitoring air quality using IoT technology has become increasingly popular due to its ability to provide real-time data and insights into the levels of various pollutants in the atmosphere. This is crucial for ensuring environmental safety and public health. One approach to achieving this is by employing gas sensors such as MQ2(Methane), MQ6(LPG), MQ7(Carbon Monoxide), MQ8(Hydrogen), and MQ135(Ammonia), along with additional components like a buzzer and an I2C LCD display. [8, 10].

A buzzer can be added to the system in addition to gassensors to allow for the prompt detection of possible threats by sounding a warning when the concentration of a particular gas above predetermined thresholds. For real-time visual feedback on air quality measures including gas concentrations and the overall air quality index, the system can also include an I2C LCD display. All things considered, an Internet of Things (IoT)-based air quality monitoring system can provide thoroughaccurate insights into the air quality of a given environment by combining gas sensors such as MQ2, MQ6, MQ7, MQ8, and MQ135 with a buzzer and an I2C LCD display. This allows for improved decision-making for environmental safety and public health.

- MQ-2 →Detects LPG, propane, hydrogen, and methane.
- MQ-4 →Detects methane, natural gas, coal gas.
- MQ-7 →Detects carbon monoxide.
- MQ-8 →Detects hydrogen gas.
- MQ-135 →Detects ammonia, nitrogen oxides, benzene,smoke, CO2

Sensors have three pins.

- VCC → connected to Power Supply
- GND → connected the ground
- Data → Analog/Digital


**Fig.1.1 MQ-2**

The MQ-2 functions similarly to a nose to identify gasses. Itis capable of detecting gases such as smoke, hydrogen, propane, and cooking gas. It functions by sensing changes in the gasses that contact it. This sensor functions effectively ata range of temperatures and relative humidity. It is good at identifying gasses with a high potential for flames. It notifiesa computer of the amount of gas it detected when it detects a gas. People use it to look for gas leaks in companies and residences, as well as to look for fires and assess the air.

MQ6 is primarily intended to detect LPG (liquefied petroleum gas), propane, and butane. It is often used in applications such as gas leakage detection in home and industrial settings. One common kind of gas sensor is the MQ-6 sensor, which is mostly used to find out if there areany combustible gases in the air, such as hydrogen, butane, propane, and alcohol. It is widely used in many different applications, including industrial safety systems, gas leak detection devices, and home contexts where gas leaks from heaters or stoves need to be detected.


**Fig.1.2 MQ-6**

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The primary purpose of the MQ-7 sensor is to detect carbon monoxide (CO) gas. It is susceptible to CO levels in the atmosphere. A higher than expected concentration of CO suggests possible health risks to people. Depending on the particular application and safety regulations, several threshold values may be used to indicate whether a CO level is hazardous. Generally speaking, though, quantities more than 100 ppm (parts per million) are thought to be harmful to human health. Usually, the sensor provides an analog voltage that changes according to the airborne CO concentration.


**Fig.1.3 MQ-7**

With its specific purpose of detecting hydrogen gas in the surrounding air, the MQ-8 sensor is an essential part of gas detection systems. This sensor, which works on the basis of chemical reaction, has a great sensitivity to hydrogen, allowing it to pick up even the smallest amounts of the gas in the atmosphere. The MQ-8 sensor is mostly used in industrial environments and is an essential instrument for maintaining worker safety. In locations where hydrogen is created, stored,or consumed, memory cells, and other digital building blocks,in particular, its quick detection of hydrogen gas leakage helps minimize potential hazards like fire or explosions.

**Fig.1.4 MQ-8**

Ammonia (NH3), nitrogen oxides (NOx), alcohol, benzene, smoke, and CO2 are among the gases that can be detected using the MQ-135 sensor. The threshold values for signaling dangerous quantities of various gases can vary based on the particular gas and the application, much as the MQ-7.Ammonia, for instance, can be hazardous to human health at amounts more than 25 parts per million. Additionally, the MQ- 135 sensor has an analog output that varies according to the gasconcentration. It's crucial to remember that although these sensors are capable of identifying dangerous gas concentrations, the cutoff points at which damage is indicated may vary depending on personal sensitivity, ambient factors, and safety regulations.

**Fig.1.5 MQ-135**

## II. LITERATURE SURVEY

The effects of air pollution on people and the environment are particularly severe in large urban areas. India's ecological problems are getting worse very quickly. The primary sources of air pollution are industry and automobiles, which can lead to sinusitis and asthma among other respiratory conditions. The air quality in major cities such as Delhi, Mumbai, Kolkata, and others is poor because of the excessive emissions of hazardous gasses and carbon dioxide from automobiles and industry.

To monitor various parameters, such as urbanpollution and air quality, the system makes use of several

sensors. These sensors wirelessly transmit their data to a central location where intelligent algorithms are used to examine it in real time.[11] This aids in the decision-making of environmentalists, city planners, and health regulators. This information is available for anybody to check on user-friendly websites and applications. Moreover, the system notifies users via text message on their phones to keep them safe in the event of an issue like poor air quality. A portable participatory sensing framework called Sense [12] is used to screen one's daily activities.
The authors of a different study [13] describe a cloud-based system that finds real-time air quality data via knowledge-based discovery. Monitoring stations that are positioned in different geolocations gather the data. This system makes use of mobile clients for tracking.
An Android application that informs users about air quality was presented by Re et al. [14]. This program connects user area data with metropolitan air quality data from monitoring stations to create a ubiquitous and unobtrusive monitoring framework [15] that can be used to notify users about their daily exposure to air pollution. VehNode, a WSN platform created by Reshi et al. [16], allowed cars to track the amount of pollutants in smoke that they were releasing into the atmosphere. A WSN-based air pollution contamination measurement system for Solapur City was described by Mujawar et al. [17]. Microsensor nodes measure the electrical conductivity of the sensing layer to identify the target gas. As the gases come into contact with the sensor's surface, they are absorbed and the conductivity shifts.
In a different study, De Nazelle et al. [18] showed how environmental sensing techniques might revive people's awareness and compassion for pollution. "Air pollution is a problem that impedes economic growth, harms natural and physical capital, and endangers basic human welfare." In order to increase funding for enhancing air quality, we expect that our study will help policy makers understand the financial impact of early mortality.
We can cut harmful emissions, slow down climate change, and most crucially, save lives, by promoting healthier cities [19] and making investments in cleaner energy sources, according to Laura Tuck, Vice President for Sustainable Development at the World Bank. According to Dr. Chris Murray, Director of IHME, "the report on air pollution is a burden of disease associated with an urgent call for necessary action from the government." "Among all the various risk factors for early mortality, breathing is one area where people have limited influence over their health. Leaders in a variety of businesses, including those in health and environmental authorities, are under increasing pressure to address this issue.

## III. METHOD & METHODOLOGY

Laura Tuck, Vice President for Sustainable Development at the World Bank, says that by encouraging healthier cities
[19] and investing in cleaner energy sources, we can reduce harmful emissions, slow down climate change, and most importantly, save lives. Dr. Chris Murray, the Director of IHME, states that "the report on air pollution is a burden of disease associated with an urgent call for necessary action from the government. "One area where people have little control over their health is breathing, out of all the different risk factors for early mortality. There is growing demand on executives across a range of industries, particularly the health and environmental sectors, to address this problem.
The connectivity and data processing power of Internet of Things devices form the foundation of our system. Every sensor node has an Ethernet or Wi-Fi networking module, an Arduino or Raspberry Pi single-board computer (SBC) These nodes are arranged in a deliberate manner throughout the target region to guarantee thorough coverage of the environment being observed, enabling efficient air quality level monitoring. Wireless transmission of the gathered sensor data is made to a central cloud-based platform for analysis and storage. Here, raw sensor data is processed by sophisticated analytics algorithms to provide valuable insights on trends in air quality, concentrations of pollutants, and possible health hazards.

Our system has a buzzer alarm feature that sounds when pollution levels rise above predetermined thresholds, which improves user awareness and safety. People around are immediately alerted by this audio signal, causing them to take the appropriate safety precautions or, in the event that it becomes essential, leave the area. In the event of dangerous air quality conditions, the system can also promptly notify emergency services or other authorities through notifications.

In addition, our system provides a number of extra features to improve functionality and usability. Users can stay updated about changes in air quality levels pertinent to their needs by, for instance, setting customized notifications based on particular pollutant thresholds or time intervals. In order to aid users in visualizing air quality data both spatially and temporally and to promote a greater knowledge of environmental trends and patterns, the system also incorporates interactive maps and visualizations.

The suggested air quality monitoring system, which uses IoT capabilities to deliver real-time insights into air quality levels, represents a substantial leap in environmental monitoring technology. Our system monitors air quality parameters continuously and sends out timely alerts and notifications in order to enable people and communities to take proactive steps to safeguard their health and well-being in the face of air pollution issues.

**Fig.3.1 Raspberry Pi Pico W Version**

The Raspberry Pi PICO is an innovative new device that the Raspberry Pi Foundation has unveiled and it's creating a lot of talk in the community. This diminutive yet potent development board is the most economical and small product that the Raspberry Pi Foundation has ever offered. It is notable for both its small size and extremely low cost. The Raspberry Pi PICO is unique because of its in-house, Raspberry Pi Foundation- developed RP2040 Microcontroller chip. With its first dual- core ARM Cortex M0+ CPU, this chip combines power and affordability. Popular programming languages like C/C++ and MicroPython are also supported by the RP2040, which makes it a great option for novices wishing to get into coding.


**Fig.3.216X2 LCD**

There are several uses for LCD (Liquid Crystal Display) screens, which are electrical display modules. A 16x2 LCD display is a fairly basic module that is widely utilized in many different kinds of circuits and gadgets. Compared to other multi-segment LEDs particularly those with seven segments, these modules are preferable. The reasons are as follows: LCDs can display special and even custom characters (unlike in seven segments); they are inexpensive; they are easily programmable; and they can display animations and other content. An LCD with a 16x2 matrix may show up to 16 characters on each of its two lines. Every character on this LCD is shown as a 5 by 7 pixel matrix.

There are two registers on this LCD:Command and Data.

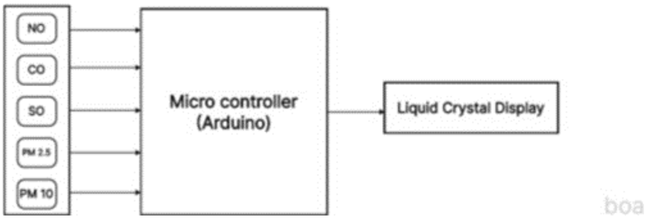


**Fig.3.3Air Monitoring using Arduino Board**

When it comes to air monitoring, Arduino is more limited than Raspberry Pi. Due to its limited processing power and memory, Arduino is unable to do complex data analysis, which is necessary for air quality monitoring. Additionally, the lack of networking inherent into Arduino means that extra modules are needed for connectivity, which increases complexity and cost. On the other hand, the Raspberry Pi Zero W has built-in WiFi, which makes data transfer and remote monitoring easier. Although beginner-friendly, Raspberry Pi's programming environment is more versatile than Arduino's because it supports languages like Python, which are essential for data analysis and Internet of Things applications. Arduino is less compatible with external sensors, which could involve special programming and integration work. The Raspberry Pi provides greater compatibility with sensors thanks to its USB and GPIO connections. Because of this, Arduino is a great tool for do-it- yourself projects, but its processing power, networking, and programming flexibility are limited.

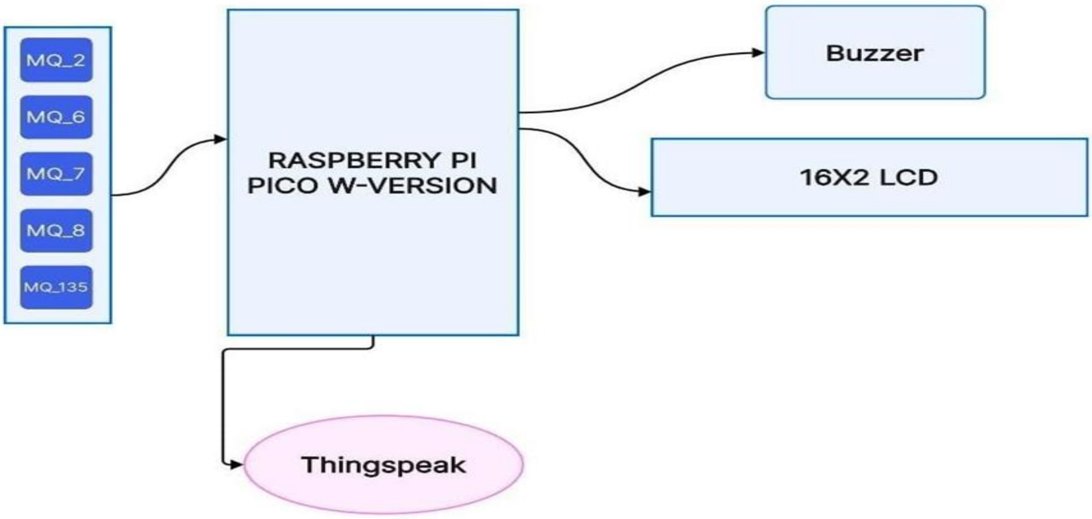


**Fig.3.4 Implementation of Air Monitoring System using RaspberryPi**

Comprehensive monitoring capabilities are provided bythe air quality monitoring system that uses an LCD as theoutput, ThingSpeak as the cloud platform, MQ2, MQ6, MQ7, MQ8, and MQ135 gas sensors as inputs, and a Raspberry Pi Zero W (Pi Zero W) as the controller.First, the Raspberry Pi Zero W acts as the main processor, making use of its integrated Wi-Fi and Bluetooth as well as its computing capability. The MQ2 gas sensor detects smoke and combustible gases, the MQ6 gas sensor detects LPG and butane, the MQ7 gas sensor detects carbon monoxide, the MQ8gas sensor detects hydrogen gas, and the MQ135 sensor monitors air quality. Real-time data on numerous contaminants and gases present in the environment is provided by these sensors.

The Raspberry Pi Zero W uses the GPIO (General Purpose Input/Output) pins for sensor interface while gathering sensor data and processing it using Python applications. Wi-Fi connectivity is then used to send the gathered data to ThingSpeak, a cloud platform for IoT applications. Users can track historical data, visualize data, and analyze it with ThingSpeak to keep an eye on changes in air quality over time and in various places.The system also has a local output LCD (Liquid Crystal Display) that shows current data on air quality metrics like gas concentrations and pollutant levels. With no need to access the cloud platform, the LCD improves user interaction and gives instant feedback on the state

of the air quality.
All things considered, the Raspberry Pi Zero W, gas sensors, ThingSpeak, and LCD display in this air quality monitoring system provide a complete solution for tracking andevaluating air quality, meeting the needs of both on-site and remote monitoring with in-depth data insights.

**THINGSPEAK**

Our project relies heavily on ThingSpeak, which provides theframework for organizing, processing, and displaying data fromour Internet of Things devices. Its many qualities, which areessential to guaranteeing the effectiveness and success of ourproject, are what make it significant.
First of all, ThingSpeak's feature for real-time data monitoring is invaluable. It enables us to monitor sensor data continually, giving us quick insights into system performance, ambient conditions, and any other factors that are critical toachieving the goals of our project. Our capacity to monitor inreal-time enables us to react quickly to changes or anomalies found by our sensors and to make well-informed decisions.
Furthermore, ThingSpeak has powerful data visualization capabilities that let us design unique dashboards and charts that clearly show the trends in our sensor data. In addition to improving our comprehension of the data, these visualizations help project stakeholders communicate and interpret the information more easily.
Additionally priceless is the remote access and control functionality that ThingSpeak offers. It guarantees flawless functioning and management even in remote or inaccessible locations by allowing us to monitor and control our IoT devicesfrom any location with an internet connection.
We can run complex analyses and calculations on our sensor data thanks to ThingSpeak's data analysis features, which also integrate with MATLAB. We can identify trends, gather insightful information, and improve the performance ofour project by utilizing MATLAB's robust algorithms to makedata-driven decisions.
Finally, ThingSpeak is a great option for projects of all sizesand complexity due to its flexibility and scalability.
ThingSpeak offers the infrastructure and resources required to handle a network of linked devices or a single sensor, enablingus to scale our project efficiently.

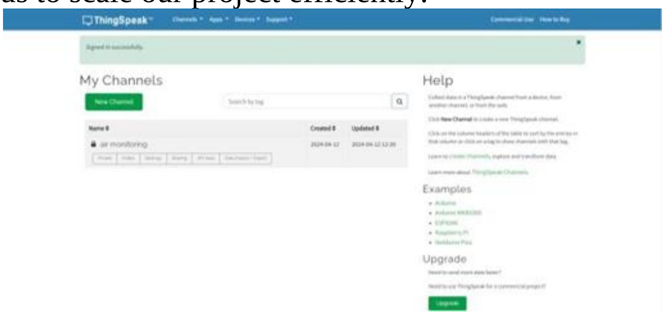


**Fig.3.5 Thingspeak Home Page**

## IV. RESULTS & DISCUSSIONS

ThingSpeak has an extensive collection of graphs that clearly show the dynamic range of any MQ sensor over time. For monitoring changes in gas concentrations and surrounding conditions, these graphs are essential tools.
The MQ2 sensor graph shows a trendline that fluctuatesover time to show variations in the quantities of combustible gases and smoke. The graph's peaks and troughs show times when gas concentrations were higher or lower, offeringinformation about possible fire risks and air quality problems.
Now let's look at the MQ6 sensor graph, which shows how the levels of butane and LPG fluctuate over time. We can identify trends in gas concentration by looking at the graph, which helps us find gas leaks or changes in the amount ofLPG in the surrounding air.

A visual representation of the carbon monoxide (CO) levelsover time is provided by the MQ7 sensor graph. The graph'sfluctuations show areas with excessive CO concentrations, whichcould be signs of interior pollution or combustion events thatneed to be attended to.It next switches to the MQ8 sensor graph, which shows changes in the concentration of hydrogen gas over time. Changes in hydrogen concentration are represented by the graph's peaksand valleys, which let us keep an eye out for hydrogen leaks andevaluate the security of hydrogen-based systems. The MQ135 sensor graph offers information on the concentrations of air pollutants such CO2, benzene, and ammonia. We can analyse trends in air quality and locatepossible pollution sources by looking at the graph, which shows variations in pollutant concentrations over time.

In conclusion, these graphs do a good job of displaying the range of each MQ sensor's response over time to shifting environmental conditions. We can proactively resolve safety concerns, optimize system performance, and guarantee a safer and healthier environment for everyone by regularly monitoring these graphs.

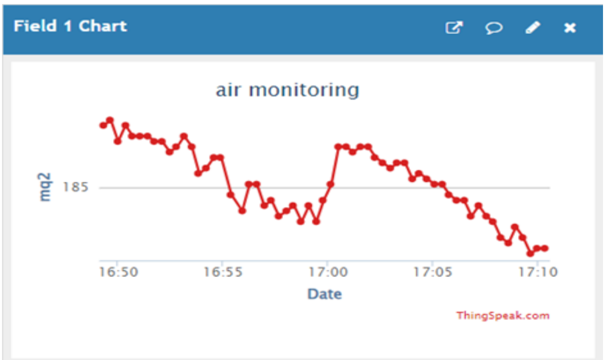


**Fig.3.6 MQ-2 Observations**

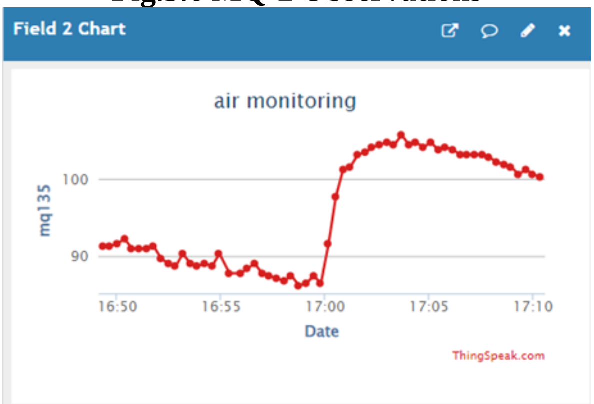


**Fig.3.7 MQ-135 Observations**

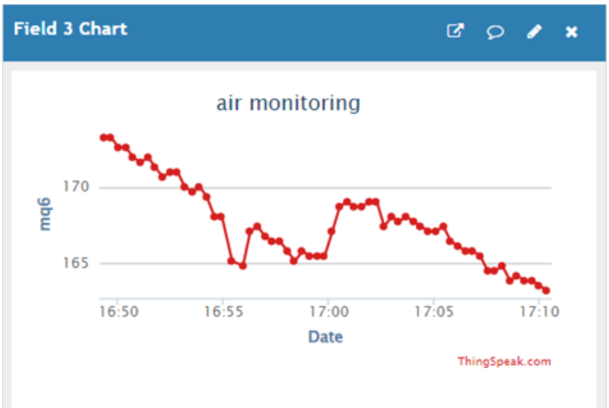


**Fig.3.8 MQ-6 Observations**

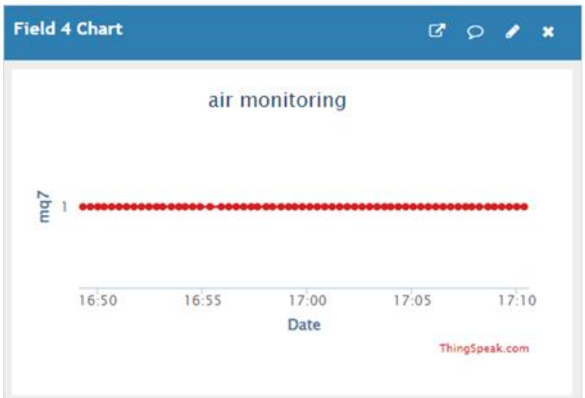


**Fig.3.9 MQ-7 Observations**

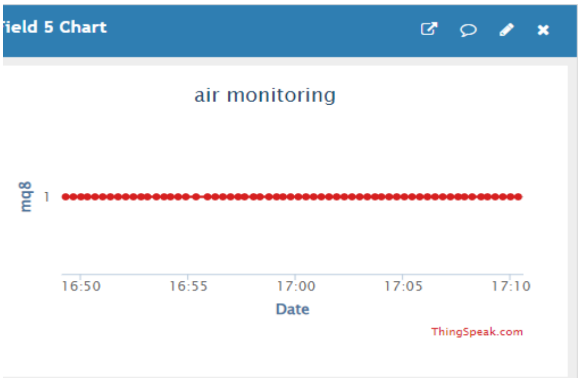


**Fig.3.10 MQ-8 Observations**

## V. CONCLUSION

Using a Raspberry Pi for air quality monitoring and gas sensors MQ2, MQ6, MQ7, MQ8, and MQ135 combined createsa potent system that monitors our air quality in real time. These sensors can detect a wide range of gases, from potentially hazardous ones like carbon monoxide to pollutants that have an impact on the environment. They are like tiny detectives. We may communicate the data that these sensors gather to a central server or cloud platform by connecting them to the Internet of Things (IoT). It functions similarly to transmitting a message toa control centre so that specialists can examine the data. This enables us to comprehend the state of our air quality and any health effects. Just picture having this information at your fingertips, available via a mobile app or website. You may do an air quality check in your neighbourhood, at work, or even at your preferred park. You could tell at a look if it's okay to go outside or if you need to take extra safety measures.

However, we won't stop there. We're upgrading our system to include a buzzer alarm, which functions as a loudspeaker and notifies us if the air quality unexpectedly deteriorates. It's our method of admonishing you to pay attention! Something is off in this place." And we're including an LCD display for individuals who are better with pictures.

It serves as our little billboard, informing us of the state of the air quality at any given time. It's simple to comprehend and aids in monitoring daily developments. In the end, we're not simply monitoring the quality of the air by utilizing these sensors and technology together; we're also taking action to safeguard our environment and ourselves. We're remaining safe, making educated decisions, and trying to improveeveryone's access to cleaner air. It's a little start in the direction of a better, healthier future.

To sum up, an Internet of Things (IoT)-based air qualitymonitoring system that incorporates MQ2, MQ6, MQ7, MQ8, and MQ135 gas sensors provides a complete solution for the real-time assessment of environmental conditions. With the use of these sensors, a variety of gases, such as flammable gases, hydrogen, carbon monoxide, and other pollutants, can be detected and measured, offering important information about the quality of the air.

The sensor data can be transferred to a cloud-based platform or central server for storage, analysis, and display by utilizing Internet of Things technology. Through intuitive interfaces like smartphone applications or web dashboards, users can obtain this data, enabling them to make well-informed decisions regarding their activities and exposure to air contaminants.

By issuing audible notifications when pollutant levels abovepredetermined thresholds, a buzzer alarm system offers an added degree of security and encourages early action to reduce potential threats.

Moreover, the incorporation of an I2C LCD display moduleprovides graphical feedback on air quality measurements inreal-time, augmenting user consciousness and simplifying environmental condition monitoring.

All things considered, MQ series gas sensors and Internet of Things (IoT)-based air quality monitoring systems are essential for advancing environmental sustainability, public health, and safety. These systems help to improve overall air quality and people's quality of life by continually monitoring air quality parameters, identifying sources of pollution, and enabling preventive solutions.

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