International Journal of Artificial Intelligence and Communication Networks
Volume: 02, Issue: 02, April -June 2026, pp: 42-51
ISSN: 3071-3358

# IoT Based Air Quality Monitoring And Air Purifier System

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***Abstract***

*Air pollution has become a serious environmental and health concern worldwide, especially in urban and industrial regions. This project presents an IoT-based air quality monitoring and air purifier system designed to detect harmful gases and improve indoor air conditions. The system uses a Raspberry Pi Pico W microcontroller with built-in Wi-Fi for real-time monitoring and cloud connectivity. Sensors such as MQ135, MQ7, MQ2, and DHT11 are used to measure gas concentration, temperature, and humidity. When pollutant levels exceed a predefined threshold, the system automatically activates a purifier using UV LEDs and a fan. Data is displayed on an OLED screen and uploaded to the cloud for remote monitoring via ThingSpeak. It provides real-time alerts and ensures better air quality management.*

***Keywords:*** *IoT, Air Quality Monitoring, MQ135 Sensor, Raspberry Pi Pico W, Air Purifier, ThingSpeak.*

## Introduction

Air pollution has emerged as one of the most critical environmental challenges affecting public health and sustainable development across the world. Rapid urbanization, industrial growth, increasing vehicular emissions, and indoor pollution sources have significantly degraded air quality in both residential and commercial environments. Exposure to harmful gases such as carbon monoxide (CO), ammonia ($NH_3$), volatile organic compounds (VOCs), and smoke can lead to respiratory disorders, cardiovascular diseases, eye irritation, and other long-term health complications. Conventional air quality assessment methods mainly rely on fixed monitoring stations that provide limited spatial coverage and are unable to deliver continuous monitoring at the individual or household level. Therefore, there is a growing need for intelligent, low-cost, and real-time monitoring systems capable of continuously assessing indoor air quality and providing timely alerts. [1]

The Internet of Things (IoT) has significantly transformed environmental monitoring by connecting sensors, embedded controllers, cloud platforms, and communication networks into a unified system. IoT enables continuous acquisition of environmental data, remote accessibility, automated decision-making, and real-time visualization of measured parameters. Through wireless communication and cloud integration, air quality information can be monitored from any location, allowing users to respond immediately whenever pollutant concentrations exceed safe limits. These capabilities have made IoT one of the most promising technologies for smart environmental monitoring applications. [6]

Gas sensors have become essential components in modern air quality monitoring systems because of their ability to detect hazardous pollutants with high sensitivity. Sensors such as MQ135, MQ7, and MQ2 are widely used for measuring air pollutants including carbon monoxide, smoke, LPG, ammonia, benzene, and other harmful gases. When combined with environmental sensors such as DHT11 for measuring temperature and humidity, these sensing devices provide a comprehensive assessment of indoor environmental conditions. The simultaneous monitoring of multiple parameters improves measurement reliability and supports more accurate evaluation of air quality. [9]

***Received:*** *11-04-2025*
***Revised:*** *07-05-2026*
***Accepted:*** *10-06-2026*
***Published:*** *16-06-2026*
***Citation:*** *"IoT Based Air Quality Monitoring And Air Purifier System ", ijaicn, vol. 2, no. 2, pp. 79–85, April. 2026,*

International Journal of Artificial Intelligence and Communication Networks
Volume: 02, Issue: 02, April -June 2026, pp: 42-51
ISSN: 3071-3358

The availability of compact embedded controllers has further simplified the development of intelligent environmental monitoring systems. The Raspberry Pi Pico W has attracted considerable attention because of its built-in Wi-Fi connectivity, low power consumption, high processing capability, and ease of programming. These features enable seamless integration of multiple sensors with cloud platforms, making the controller suitable for real-time air quality monitoring and automated control applications. Its wireless communication capability also eliminates the need for additional networking hardware, thereby reducing system complexity and implementation cost. [11]

Cloud computing has become an important component of IoT-based monitoring systems by enabling remote data storage, visualization, and analysis. Platforms such as ThingSpeak allow continuous uploading of sensor readings, graphical representation of environmental parameters, historical trend analysis, and automated alert generation. Cloud-based monitoring not only improves accessibility but also assists users in identifying long-term changes in air quality that may otherwise remain unnoticed through conventional monitoring approaches. [5]

Automatic air purification has gained increasing importance in smart environmental management systems. Instead of simply detecting pollution, modern monitoring systems can activate purification devices whenever pollutant concentrations exceed predefined safety limits. Components such as UV LEDs, exhaust fans, and filtration units can be controlled automatically through embedded controllers, enabling immediate reduction of airborne contaminants without requiring manual intervention. This combination of monitoring and automatic purification significantly improves indoor air quality while reducing health risks associated with prolonged pollutant exposure. [4]

Recent advances in low-power wireless communication and cloud-enabled embedded systems have further improved the reliability and scalability of smart environmental monitoring solutions. Continuous data collection, wireless transmission, cloud analytics, and automated device control together provide a complete framework for intelligent air quality management. Such integrated systems support both residential and industrial applications by offering real-time environmental information, early warning notifications, and efficient pollution control mechanisms. [8]

Considering these technological developments, this research proposes an IoT-Based Air Quality Monitoring and Air Purifier System using Raspberry Pi Pico W, MQ135, MQ7, MQ2, and DHT11 sensors. The proposed system continuously monitors harmful gases and environmental conditions, displays sensor readings on an OLED screen, uploads the collected information to the ThingSpeak cloud platform, and automatically activates a UV LED-based air purifier and fan whenever pollutant concentrations exceed predefined threshold values. The objective is to provide an economical, reliable, and intelligent solution for improving indoor air quality through continuous monitoring and automated purification. [14]

**Literature Review**

**S. Kumar, R. Gupta, and P. Sharma** developed an IoT-based smart air quality monitoring system for indoor and outdoor environments using multiple environmental sensors. Their research demonstrated that continuous monitoring through wireless sensor networks improves pollutant detection while providing users with timely information regarding environmental conditions. The proposed system highlighted the importance of real-time monitoring for effective air quality management. [1]

**A. K. Mishra, P. Verma, and R. Singh** presented a real-time air pollution monitoring system based on IoT and wireless sensor networks. Their work focused on collecting environmental data from distributed sensing devices and transmitting the information through wireless communication for centralized analysis. The study showed that IoT technology significantly improves monitoring efficiency compared to conventional pollution assessment methods. [2]

**H. Zhang, Y. Li, and X. Wang** proposed a cloud-connected air quality monitoring system utilizing low-cost IoT sensors for environmental observation. Their architecture enabled continuous transmission of air quality data to cloud servers, allowing users to visualize sensor readings remotely and perform historical trend analysis. The research demonstrated that cloud integration enhances accessibility and supports efficient environmental monitoring. [3]

**S. S. Raut, V. B. Gaikwad, and P. R. Patil** designed an IoT-based smart air purification system that combines environmental monitoring with automatic purifier activation. Their system continuously monitored indoor pollutant concentrations and activated purification devices whenever air quality deteriorated. Experimental results confirmed that automated control mechanisms effectively improve indoor environmental conditions while reducing user intervention. [4]

**M. A. Islam, T. Rahman, and M. S. Hossain** introduced a ThingSpeak-based IoT framework for environmental monitoring applications. Their study demonstrated the advantages of cloud platforms in collecting, storing, and visualizing sensor information in real time. The proposed framework also supported remote monitoring and simplified long-term environmental data analysis through interactive dashboards. [5]

**P. K. Das, A. Roy, and S. Chatterjee** developed an IoT-based indoor air quality monitoring system using ESP32 and cloud analytics. Their work integrated multiple environmental sensors with wireless communication to continuously monitor indoor pollutant levels. The study showed that cloud analytics improves environmental assessment by providing graphical visualization and long-term monitoring capabilities. [8]

**M. H. Rahman, M. T. Islam, and M. R. Amin** presented a real-time air quality monitoring system using MQ135 and DHT11 sensors integrated with IoT technology. Their research focused on measuring harmful gases, temperature, and humidity while transmitting sensor data to cloud servers for continuous observation. The proposed system demonstrated reliable sensing performance and effective environmental monitoring under varying conditions. [9]

**B. Prakash, K. Reddy, and N. Rao** proposed an IoT-enabled environmental monitoring and air pollution detection system that continuously measured atmospheric pollutants using multiple gas sensors. Their study emphasized the importance of integrating wireless communication, cloud storage, and automated notification systems to improve pollution management and public health awareness. [10]

**M. Chen, J. Wang, and Y. Zhao** developed an edge-enabled IoT architecture for intelligent indoor air quality monitoring. Their framework processed sensor data closer to the sensing devices, thereby reducing communication latency and improving system responsiveness. The research demonstrated that edge computing enhances scalability while supporting faster environmental monitoring and decision-making. [12]

**P. S. Reddy, N. B. Rao, and S. Venkatesh** proposed an integrated IoT-based air quality monitoring and automatic air purifier control system capable of simultaneously detecting pollutants and activating purification equipment. Their work demonstrated that combining real-time sensing with automated purifier control significantly improves indoor air quality while minimizing energy consumption. The proposed architecture provides an effective solution for smart homes, healthcare facilities, educational institutions, and industrial environments. [14]

**Existing System**

Traditional air quality monitoring systems are primarily designed to measure environmental pollutants using standalone gas sensors or fixed monitoring stations. These systems generally focus only on monitoring pollutant concentration and displaying the measured values locally without providing intelligent control or remote accessibility. Most conventional systems depend on manual observation, making it difficult to continuously supervise indoor air quality, especially in homes, offices, industries, and laboratories. Furthermore, they usually monitor only a limited number of environmental parameters, resulting in incomplete assessment of indoor air conditions.

Many existing air quality monitoring solutions lack automatic response mechanisms. Even when harmful gases are detected, the systems generally require manual intervention to switch on ventilation equipment or air purifiers. In addition, conventional monitoring systems often do not provide cloud connectivity, preventing users from accessing real-time environmental information remotely or maintaining historical records for long-term analysis. These limitations reduce their effectiveness in ensuring continuous air quality management and timely corrective action.

**Proposed System**

The proposed IoT-Based Air Quality Monitoring and Air Purifier System integrates multiple gas sensors, environmental sensors, cloud connectivity, and automatic purifier control into a single intelligent platform. The system employs the Raspberry Pi Pico W microcontroller with built-in Wi-Fi to continuously monitor indoor air quality using MQ135, MQ7, MQ2, and DHT11 sensors. These sensors measure pollutant concentration, carbon monoxide, smoke, temperature, and humidity simultaneously, providing a comprehensive evaluation of indoor environmental conditions.

The microcontroller continuously processes sensor data and compares the measured values with predefined safety thresholds. When pollutant concentrations exceed the allowable limits, the system automatically activates the air purification unit through a driver circuit that controls the UV LEDs and ventilation fan. Simultaneously, an audible buzzer is activated to warn nearby occupants about deteriorating air quality.

The system also uploads real-time sensor readings to the ThingSpeak cloud platform using the Wi-Fi capability of the Raspberry Pi Pico W. Users can remotely monitor environmental conditions through graphical dashboards, analyze historical data, and observe long-term air quality trends. The OLED display provides local visualization of all monitored parameters, enabling users to view the current air quality status directly at the monitoring location.

The proposed system offers continuous monitoring, intelligent decision-making, automatic purification, cloud-based data management, and real-time alert generation. These features improve indoor air quality, reduce human intervention, enhance energy efficiency, and provide a reliable solution for smart homes, offices, hospitals, educational institutions, laboratories, and industrial environments.

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**Block Diagram**

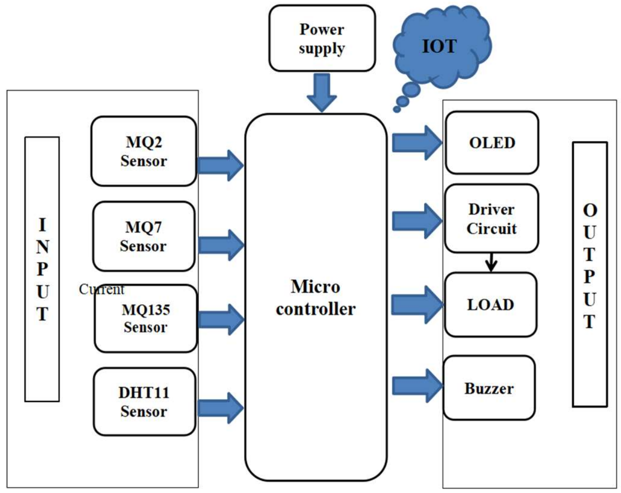


*Figure 1: Proposed Block Diagram*

**Block Diagram Description**

The proposed IoT-Based Air Quality Monitoring and Air Purifier System is designed to continuously monitor indoor air quality, detect harmful gases, and automatically activate an air purification mechanism whenever pollution levels exceed predefined safety limits. The system integrates multiple gas sensors, a microcontroller, IoT connectivity, an OLED display, a driver circuit, and an alarm unit to provide real-time monitoring and intelligent air quality management.

The power supply provides a stable DC voltage to all hardware components of the system, including the microcontroller, gas sensors, IoT communication module, OLED display, driver circuit, and buzzer. A regulated power source ensures uninterrupted operation and reliable performance during continuous environmental monitoring.

The microcontroller serves as the central processing unit of the system. It receives input data from all connected sensors, processes the measured values, compares them with predefined threshold levels, and controls the operation of the output devices. It also manages wireless communication with the IoT platform and coordinates the automatic activation of the air purifier whenever poor air quality is detected.

The MQ2 sensor is used to detect combustible gases and smoke present in the surrounding environment. It is capable of sensing gases such as LPG, methane, hydrogen, and smoke particles. The sensor continuously measures gas concentration and sends the information to the microcontroller for further analysis. When the detected concentration exceeds the permissible level, the system initiates appropriate warning and purification actions.

The MQ7 sensor is responsible for monitoring carbon monoxide (CO), which is one of the most harmful gases found in indoor and industrial environments. Carbon monoxide is colorless and odorless, making continuous monitoring essential for human safety. The sensor provides real-time CO concentration values to the microcontroller, allowing immediate detection of hazardous conditions.

The MQ135 sensor is designed to monitor overall air quality by detecting pollutants such as ammonia, benzene, carbon dioxide, alcohol vapors, smoke, and other volatile organic compounds. It serves as the primary air quality sensor in the system by providing an Air Quality Index (AQI)-related indication based on pollutant concentration. The collected data helps determine whether the surrounding air remains within safe environmental limits.

The DHT11 sensor measures ambient temperature and relative humidity. These environmental parameters are important because temperature and humidity directly influence indoor comfort levels and the efficiency of air purification systems. The sensor continuously transmits environmental measurements to the microcontroller, allowing comprehensive monitoring of indoor conditions.

The IoT module enables wireless communication between the monitoring system and the cloud platform. Using the built-in Wi-Fi capability of the Raspberry Pi Pico W, sensor readings are uploaded to the ThingSpeak cloud platform for real-time visualization, remote monitoring, and historical data storage. This allows users to monitor indoor air quality from any internet-connected device and receive notifications when abnormal conditions occur.

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The OLED display provides a local monitoring interface by displaying real-time values of gas concentrations, temperature, humidity, and overall system status. Users can immediately observe current environmental conditions without requiring external monitoring equipment.

The driver circuit acts as an interface between the low-power microcontroller and the air purification hardware. Since devices such as fans and UV LED modules require higher operating current, the driver circuit amplifies the control signals generated by the microcontroller and safely switches the purifier components on and off.

The load represents the air purification unit, which may consist of a ventilation fan, UV LED sterilization module, air filter, or other purification devices. Whenever pollutant concentrations exceed predefined threshold values, the microcontroller activates the driver circuit, which in turn powers the air purifier to remove harmful contaminants and improve indoor air quality automatically.

The buzzer functions as an audible alert device. If dangerous gas concentrations or abnormal environmental conditions are detected, the microcontroller immediately activates the buzzer to warn occupants about the deteriorating air quality. The audible warning enables users to take prompt corrective action while the purifier operates automatically.

The output section includes the OLED display, driver circuit, air purifier load, and buzzer. Together, these components provide both visual and audible indications of system status while automatically controlling the purification process. The integrated operation ensures continuous monitoring, immediate warning generation, and automatic improvement of indoor air quality.

Overall, the proposed system combines multi-gas sensing, environmental monitoring, wireless IoT communication, cloud-based data management, and automated air purification into a single intelligent platform. By continuously monitoring harmful gases, temperature, and humidity, and by automatically activating the purification system whenever pollution exceeds safe limits, the system provides an efficient, economical, and reliable solution for maintaining healthy indoor air quality in homes, offices, laboratories, hospitals, and industrial environments.

**Schematic Diagram :**

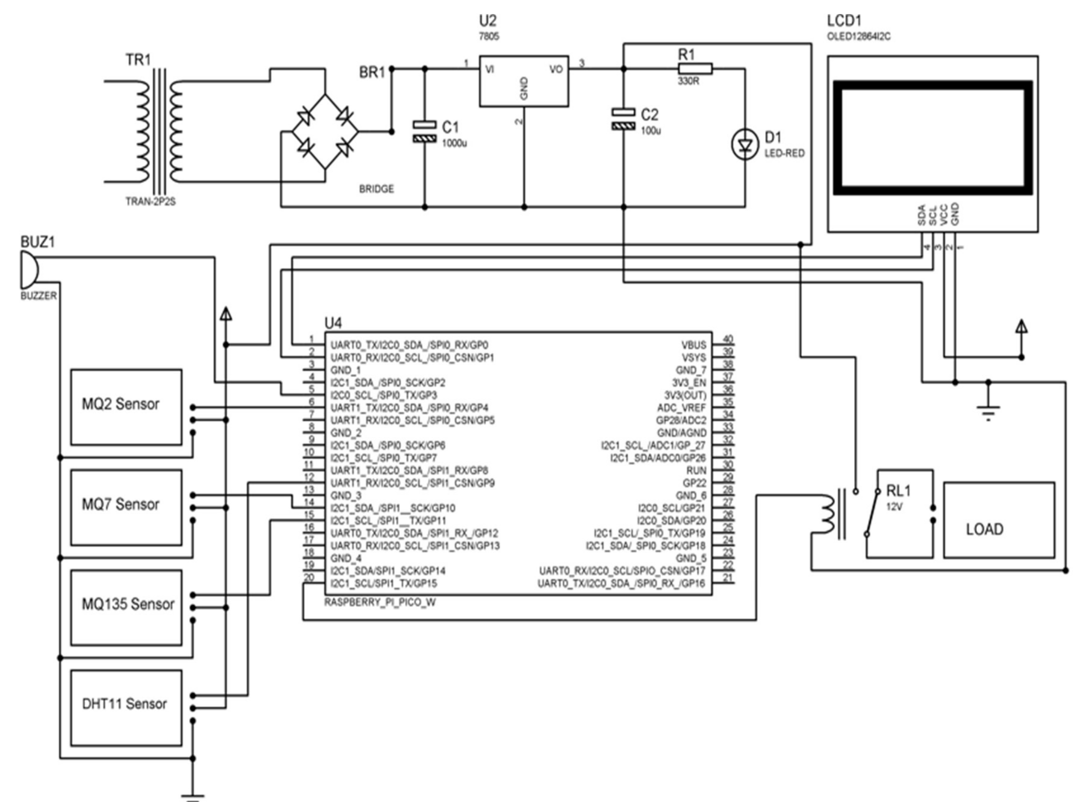


*Figure 2: Circuit Schematic Diagram*

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**Implementation Flowchart**

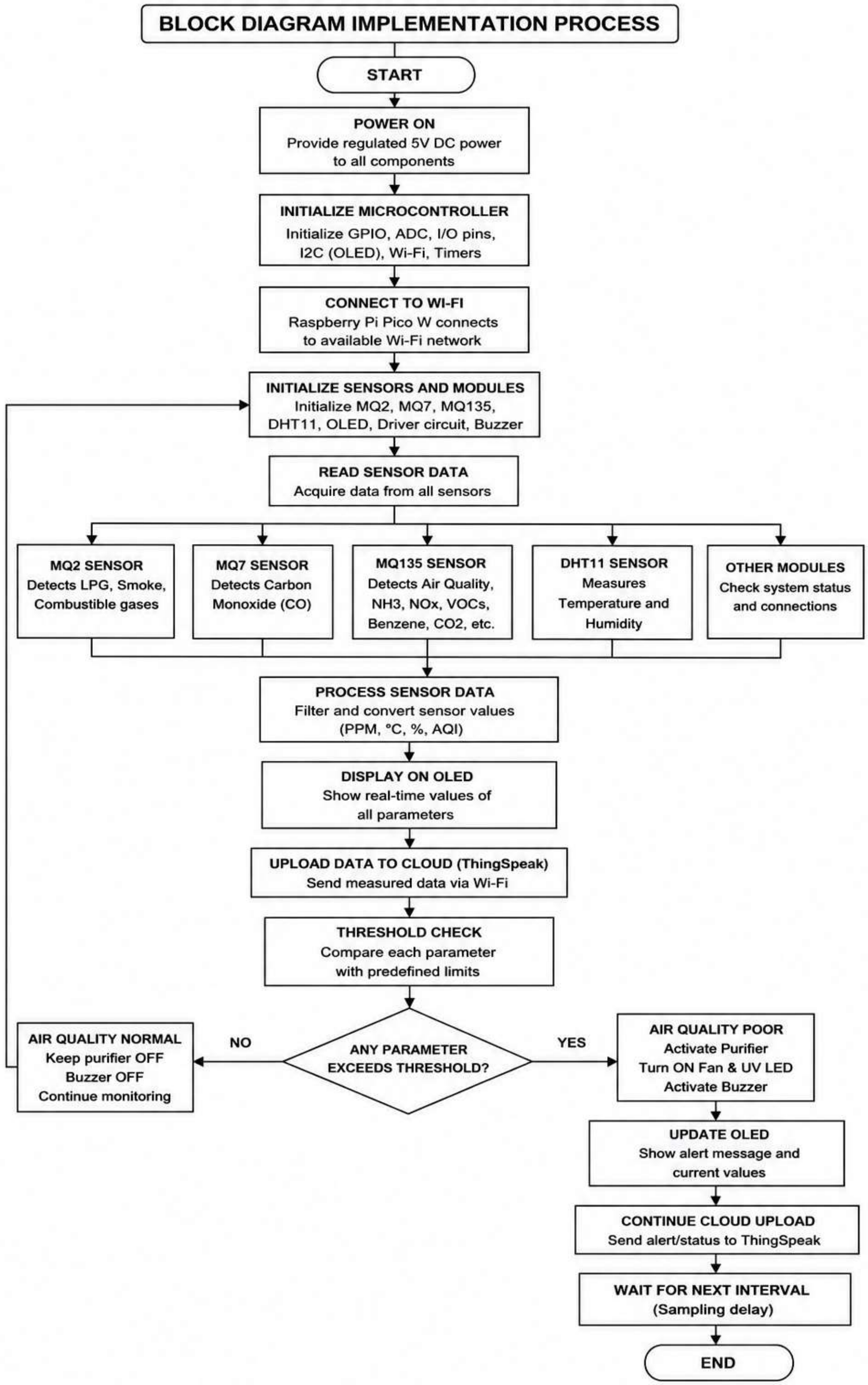


*Figure 3 : Flowchart*

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**Results :**

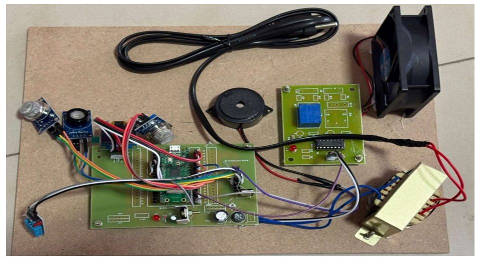

*Fig.4: Hardware Kit in OFF Condition*

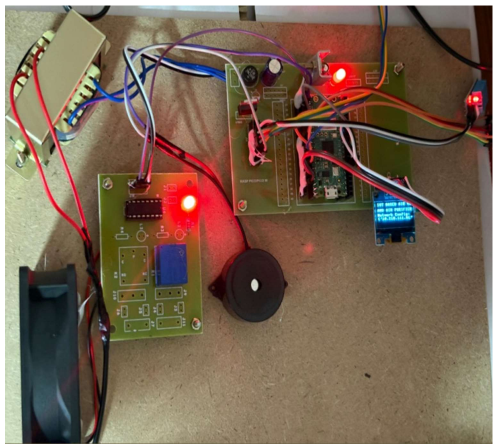

*Fig.5 : Hardware Kit in ON Condition*

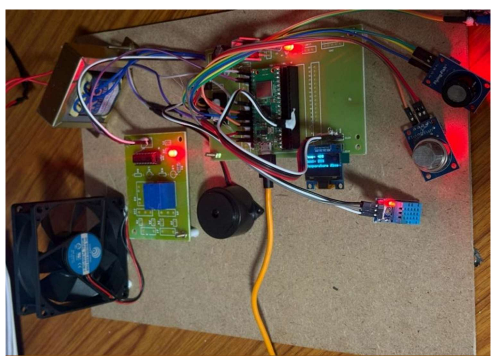

*Fig.6 : Display shows Temperature and Humidity values*

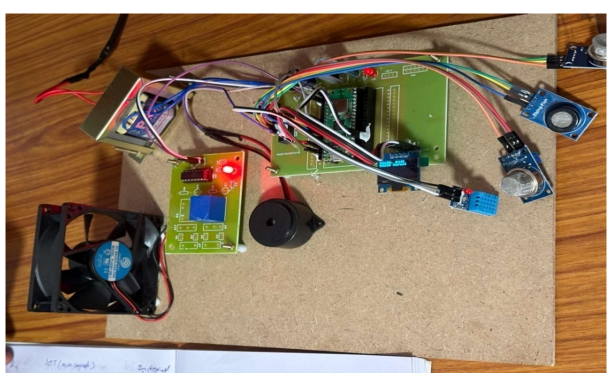

*Fig.7: Display shows MQ135 sensor Value*

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Volume: 02, Issue: 02, April -June 2026, pp: 42-51
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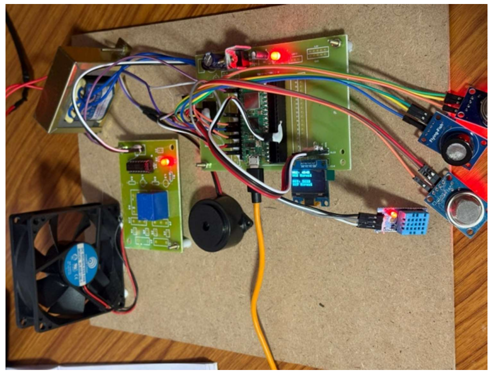

*Fig.8 : Display shows MQ2 and MQ7 sensor values*

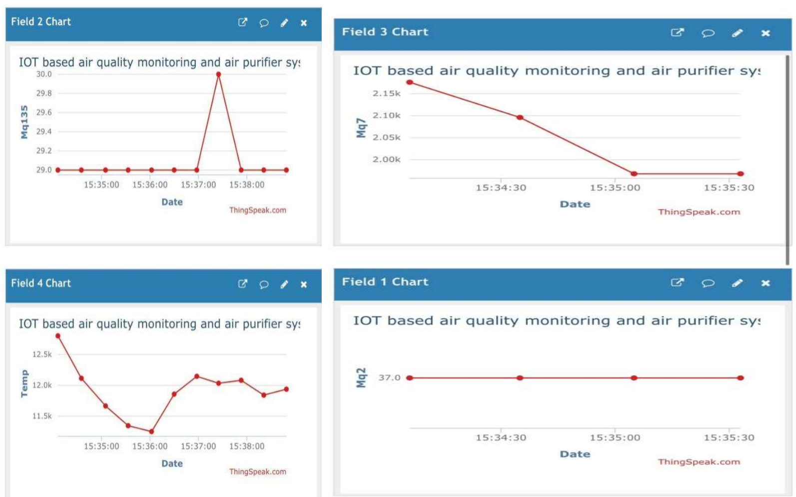


*Fig.9 : Displaying sensors data through Thingspeak*

Figure 4 illustrates the graphical representation of the sensor data uploaded to the ThingSpeak cloud platform. The Raspberry Pi Pico W transmits the collected sensor readings to the cloud through its built-in Wi-Fi connectivity, where the information is stored for real-time visualization and future analysis. The plotted graph shows the variation of different air quality parameters over a period of time, allowing users to observe environmental changes and identify pollution trends. This cloud-based monitoring feature enables remote access to the system from any location with an internet connection, thereby improving the effectiveness and convenience of air quality monitoring.

Figure 5 presents the complete hardware setup of the proposed system in the OFF or idle state. In this condition, the power supply is connected to the circuit; however, the system has not yet started processing sensor data. The Raspberry Pi Pico W remains in standby mode, waiting for initialization. Since no sensor readings are being processed, the OLED display, driver circuit, air purifier, and buzzer remain inactive. This state represents the initial condition of the system before real-time monitoring begins.

Figure 6 shows the hardware setup after the system has been powered on and initialized. At this stage, all sensors and hardware components become operational. The Raspberry Pi Pico W initializes the MQ2, MQ7, MQ135, and DHT11 sensors and starts collecting environmental data continuously. The measured sensor values are processed by the microcontroller and transmitted to the ThingSpeak cloud platform for remote monitoring. Simultaneously, the OLED display becomes active and begins presenting the measured parameters in real time, indicating that the system is functioning normally.

Figure 7 displays the real-time temperature and humidity values obtained from the DHT11 sensor on the OLED display. The sensor continuously measures the surrounding environmental conditions, and the Raspberry Pi Pico W updates the displayed values at regular intervals. The OLED provides a clear and easy-to-read interface, allowing users to observe the current temperature and humidity instantly. These measurements are useful for evaluating indoor environmental comfort and supporting effective air quality management.

Figure 8 illustrates the air quality measurements obtained from the MQ135 sensor. This sensor is designed to detect various harmful gases, including ammonia, carbon dioxide, benzene, smoke, and other volatile organic compounds present in the atmosphere. The measured values are processed by the microcontroller and displayed on the OLED while simultaneously being uploaded to the ThingSpeak cloud platform. Higher sensor readings indicate deteriorating air quality and increased pollutant concentration, prompting the system to activate the purification mechanism whenever the predefined threshold is exceeded.

Figure 9 presents the OLED display showing the sensor readings acquired from the MQ2 and MQ7 gas sensors. The MQ2 sensor continuously monitors combustible gases such as LPG, methane, hydrogen, and smoke, whereas the MQ7 sensor specifically detects carbon monoxide (CO), a hazardous and odorless gas. The Raspberry Pi Pico W processes these sensor values in real time and displays the measured concentrations on the OLED screen. These sensors play a significant role in improving safety by providing early detection of harmful gas leakage and toxic environmental conditions. When the detected gas concentration exceeds the predefined safety limit, the system automatically activates the air purifier and generates an audible warning through the buzzer.

## Conclusion

The proposed IoT-based Air Quality Monitoring and Air Purifier System provides an efficient, economical, and reliable solution for continuous monitoring and improvement of indoor air quality. By integrating MQ135, MQ7, MQ2, and DHT11 sensors with the Raspberry Pi Pico W and ThingSpeak cloud platform, the system continuously measures environmental parameters and enables real-time remote monitoring through Wi-Fi connectivity. The automatic activation of the air purifier using the driver circuit, UV LEDs, and fan ensures immediate reduction of harmful pollutants whenever unsafe air quality conditions are detected. The OLED display and buzzer further enhance the system by providing instant visual and audible alerts to users.

The experimental implementation demonstrates stable sensor performance, reliable wireless communication, and accurate real-time monitoring of air quality parameters. The cloud platform successfully stores and visualizes environmental data, allowing users to monitor pollution trends and access historical records from any location. Compared with conventional monitoring systems, the proposed solution offers improved automation, lower implementation cost, continuous monitoring, and intelligent purification without requiring manual intervention.

Overall, the developed system represents a practical solution for maintaining healthy indoor environments in homes, offices, hospitals, educational institutions, laboratories, and small industries. Its modular architecture also provides opportunities for future enhancement through artificial intelligence-based air quality prediction, machine learning algorithms, mobile application integration, and advanced filtration technologies, making it suitable for next-generation smart environmental monitoring systems.

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