AIR QUALITY MONITORING SYSTEM BASED ON IOT USING RASPBERRY PI PICO

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***Abstract*—**The Air Quality Monitoring System based on IoT using Raspberry Pi is a project aimed at developing an efficient and real-time solution for monitoring and analyzing air quality parameters. The system utilizes Raspberry Pi, along with various sensors, to collect data related to air quality, such as pollutants, temperature, humidity, and air pressure. This data is then transmitted wirelessly to a cloud-based platform, where it is processed and analyzed. The system provides users with real-time information on air quality, alerts for poor air quality conditions, and historical data for analysis and decision-making. This project contributes to environmental monitoring and enables individuals and organizations to make informed choices for better air quality management.

Keywords—Internet of Things (IOT), Air Quality Monitoring, Raspberry pi, Node MCU, Cloud Computing.

INTRODUCTION

Air pollution is caused due to the presence of harmful particles, harmful materials and bio-hazardous molecules in earth atmosphere layers [3]. It has adverse impact on living organisms such as humans, animals, food crops and can also damage built and natural environment. It may result in allergies, harmful diseases such as cardio vascular diseases, lungs diseases and can also cause death. The environment group Greenpeace in January released a report that has estimated every year nearly 1.2 million Indian die because of air borne pollutants [5]. The quality of air we breathe is of paramount importance for our health and well-being. Rapid industrialization and urbanization have led to increased air pollution levels, which pose significant risks to human health and the environment. Monitoring air quality is crucial in identifying pollution sources, assessing exposure risks, and implementing appropriate measures for mitigation [1]. The Air Quality Monitoring System based on IoT using Raspberry Pi offers an innovative solution to monitor air quality parameters in real-time. It leverages the Internet of Things (IoT) technology, where multiple sensors are connected to a Raspberry Pi, a credit-card-sized computer, to collect data on various air quality parameters. These parameters include the concentration of pollutants, temperature, humidity, and air pressure [2]. The system also includes features such as alerts and notifications, where users

receive warnings when the air quality reaches unhealthy levels. Additionally, historical data is stored and made available for analysis and trend identification, aiding policymakers, researchers, and environmentalists in understanding air quality patterns and developing effective strategies for pollution control [4].

1 LITERATURE REVIEW

Xing Liu, Orlando [6] The authors have conducted a comparative analysis that delves into the realms of smart sensors, objects, devices, and things within the Internet of Things (IoT) landscape, presenting diverse interpretations of IoT's definitions and concepts while highlighting both the distinctions and commonalities between smart objects and smart things in this context.

In their work, Baralis, Elena et al. [9] introduce an innovative Business Intelligence Engine (APA) aimed at raising public awareness regarding air quality and its susceptibility to various factors, including pollutants, toxic gases, and more. The system conducts comprehensive analyses of air pollution from multiple angles, incorporating meteorological data, pollutant information, and traffic data. Its primary objective is to empower individuals by highlighting how their actions can contribute to the degradation of air quality. Phala, Kgoputjo et al. [7] introduced an Air Quality

Monitoring System (AQMS) conforming to the IEEE/ISO/IEC 21451 standard. This advanced system employs electrochemical and infrared sensors to measure concentrations of gases such as Carbon Monoxide (CO), Methane (CH4), radioactive micro particles.The collected data is securely stored in a dedicated data server for further analysis and reporting.

Shete, R., and Agrawal, S. [8], have outlined a city environment monitoring framework that employs costeffective Raspberry Pi technology for system implementation. This framework encompasses the measurement of critical parameters including carbon monoxide (CO), carbon dioxide (CO2), temperature, and atmospheric pressure. However, it's worth noting that the framework lacks a specific focus on particulate matter, which represents a noteworthy gap in the holistic monitoring of the environment.

III. SYSTEM DESIGN

Figure 1 illustrates the simplified diagram of our proposed system, with the Raspberry Pi pico serving as the central control node and also wifi module. The system utilizes an array of sensors designed to detect various environmental parameters, including Carbon Monoxide (CO), temperature, humidity, smoke particles and methane (CH4). And there are external output devices such buzzer and LCD display.

To facilitate seamless data collection and communication, the sensors are connected to raspberry pi pico. Raspberry Pi pico establishes a robust interface with the wifi module through transmission, receiver terminals and data pin [2]. This configuration enables continuous data transmission from the sensors through Raspberry Pi and then from wifi module to cloud-based storage, leveraging its robust network connectivity.

A Wi-Fi module is a compact and self-contained piece of technology that has revolutionized the way devices connect to the internet and communicate with each other. These modules are integral components in numerous devices, ranging from smartphones and laptops to IoT devices and smart home appliances. They enable wireless connectivity, which has become a fundamental part of our daily lives. At its core, a Wi-Fi module consists of both hardware and software components. The hardware typically includes an integrated circuit with a Wi-Fi radio transceiver, an antenna for wireless communication, and various interfaces for connecting to a device's main controller or microcontroller.

Key sensor components include the MQ3 sensor, A smoke sensor, also known as a smoke detector is a device used to detect the presence of smoke particles in the air. Smoke sensors play a crucial role in fire safety systems by providing early detection of smoke, alerting occupants, and triggering appropriate actions to mitigate potential fire hazards. It is primarily employed for the precise measurement of particulate matter, encompassing elements such as smoke and dust in the surrounding environment.

Additionally, the DHT11 and MQ138 sensor are provided digital outputs and are utilized for the accurate measurement of temperature, humidity, and carbon monoxide concentration respectively.

A MQ138 sensor is a device that is used to detect the presence and measure the concentration of carbon monoxide gas in the surrounding environment. Carbon monoxide is a colorless, odorless, and highly toxic gas that is produced by the incomplete combustion of fossil fuels and other carboncontaining materials.

With its 16-character width and single-line layout, it's well-suited for projects where space may be limited, and where you need to display important data in a straightforward manner.

A buzzer is a small yet efficient component to add sound features to our project/system. It is very small and compact 2-pin structure hence can be easily used on breadboard, Perf Board and even on PCBs which makes this a widely used component in most electronic applications. There are two types are buzzers that are commonly available. The one shown here is a simple buzzer which when powered will make a Continuous Beep sound, the other type is called a readymade buzzer which will look bulkier than this and will produce a Beep. Beep. Beep. Sound due to the internal oscillating circuit present inside it. But, the one shown here is most widely used because it can be customised with help of other circuits to fit easily in our application.

ThingSpeak is an innovative and versatile platform designed to facilitate the collection, visualization, and analysis of data from various Internet of Things (IoT) devices and sensors. It has gained significant popularity for its ability to connect and interact with numerous IoT applications, including air quality monitoring systems, thus contributing to the advancement of environmental monitoring and data-driven decision-making. Air quality monitoring is a critical component of modern urban planning and public health management. With the increasing concerns about air pollution and its adverse effects on health and the environment, the need for accurate and real-time air quality data has never been more crucial. ThingSpeak provides an ideal solution for establishing a comprehensive and reliable air quality monitoring system. ThingSpeak enables the seamless integration of various sensors, such as particulate matter (PM), carbon monoxide (CO) into an IoT network. The Block diagram of our system has been shown in Fig.1.

Fig.1.Simplified Block diagram of Proposed System

A. Raspberry Pi Pico

The board offers 26 multifunction GPIO pins, which can be configured for digital input and output, PWM, I2C, SPI, and various other purposes. Its broad input voltage range of 1.8V to 5.5V enhances compatibility with a wide range of sensors and components. The Raspberry Pi Pico's programming options are diverse, encompassing languages like MicroPython, C/C++, and more. It employs the "CircuitPython" framework for MicroPython, simplifying code development and making it accessible to both beginners and experienced developers.Connectivity is achieved via a micro-USB port, which serves both power and data transmission purposes[2]. Furthermore, the board can act as a USB device, offering versatile use cases for various applications. In terms of physical form, the Pico is compact and lightweight, ideal for embedded projects and prototyping. Its cost-effective pricing makes it an attractive choice for hobbyists and professionals alike. One of the Pico's strengths lies in its vibrant community and strong support system. With a vast repository of tutorials, projects, and active forums, users have ample resources to draw from. Additionally, the Raspberry Pi Pico is open-source hardware, with design files and specifications available to the public, fostering an environment of collaboration and innovation. In summary, the Raspberry Pi Pico is a versatile, cost-effective, and open-source microcontroller development board. Its simplicity, robust performance, and the backing of the Raspberry Pi Foundation have made it a popular choice for those looking to explore the realm of embedded systems and IoT applications.

The Block diagram of our system has been shown in Fig.1.

Parameter	Operating voltage	Measuring range
CARBON MONOXIDE	3.3V-5V	10-10000 ppm
TEMPERATURE	3.3V-5V	0 TO 50 DEGREE CELSIUS
RELATIVE HUMIDITY	3.3V-5V	20 TO 80 % RH
PAR TICULATE MATTER(SMOKE)	3.3V-5V	300-10000 ppm
METHANE	5V	10-10000 ppm

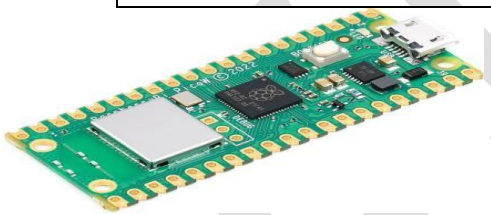

Fig.2.Image of Raspberry Pi Pico

B. Sensing and output device Unit

Sensing Unit comprises of five sensors for monitoring the air pollution. Table 1 shows the technical specifications of the four CO, Methane, Smoke sensors, Temperature, Humidity sensor. And output devices as Buzzer and 16*2 LCD display. MQ3 is a low-cost smoke sensor module has a very high sensitivity as it can even detect the fine particles having the diameter greater than 1 micron. And MQ2 is the methane sensor. MQ138 is highly sensitive to carbon monoxide / combustible gases. DHT11 is a four-pin, resistive type having digital output relative humidity and temperature sensor. A 16x1 LCD display is a small and simple screen that can show up to 16 characters in a single row. It's often used in various applications such as digital clocks, basic information displays, and embedded systems to provide a concise visual output. A buzzer is an electromechanical device that produces a sharp, audible sound when an electric current is applied, commonly used in alarms, notifications, and electronic circuit.(parts per million)

Table 1.Parameters and operating voltages

IV METHODOLOGY

The objective of the Air Quality Monitoring System based on IoT using Raspberry Pi project is to design and implement a reliable and efficient system for monitoring air quality parameters in real time. The specific objectives of the project include: Develop a system that utilizes Raspberry Pi and various sensors to collect data on air quality parameters, such as pollutants, temperature, humidity, and air pressure. Enable wireless transmission of the collected data from the Raspberry Pi to a cloud-based platform for further processing and analysis. Real-time Monitoring: Provide users with realtime information on air quality conditions through a web or mobile interface, allowing them to stay informed about the air quality in their surroundings. Alerts and Notifications: Implement a mechanism to generate alerts and notifications when the air quality reaches unhealthy levels, enabling individuals to take necessary precautions and avoid exposure to poor air quality. Data Analysis and Visualization: Store and analyze the collected data on the cloud platform, providing users with historical data, trends, and visualizations to better understand air quality patterns and make informed decisions.

V RESULT

The Air Quality Monitoring System based on IoT using Raspberry Pi offers numerous benefits, including real-time monitoring, wireless data transmission, accessibility, and scalability. It can be deployed in various settings, such as urban areas, industrial zones, and residential neighbourhood, to provide comprehensive air quality information. By raising awareness and facilitating data-driven decision-making, this system contributes to the improvement of air quality and the overall well-being of individuals and communities.

VI CONCLUSION

In conclusion, the Air Quality Monitoring System based on IoT using Raspberry Pi is an effective and reliable solution for monitoring air quality parameters in real-time. By leveraging Raspberry Pi's capabilities and integrating various sensors, the system collects data on pollutants, temperature, humidity, and other relevant indicators. The collected data is transmitted wirelessly to a cloud-based platform, where it is processed, analyzed, and made accessible to users through a web or mobile interface. This system offers several advantages, including real-time monitoring, remote access to air quality information, datadriven decision-making, and the potential for early detection of air pollution. It empowers individuals, communities, and organizations with actionable insights to protect their health and make informed choices regarding environmental conditions. By implementing an Air Quality Monitoring System based on IoT using Raspberry Pi, stakeholders can contribute to improving air quality management, identifying pollution sources, and implementing effective mitigation strategies. The system's low-cost nature and scalability make it accessible to a wide range of users, including individuals, educational institutions, research organizations, and government agencies.

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