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DESIGN AND IMPLEMENT OF POLLUTION ALARM SYSTEM

Samer Bashar Mohaisen Ali
Al-Farahidi University College of Medical Technology Department of Engineering Of Medical Device Technologies
Email: Samer2000br@gmail.com

Abstract
The escalating concerns surrounding environmental pollution necessitate the development of robust monitoring systems capable of detecting various pollutants in real-time. This project presents the design and implementation of a Pollution Alarm System (PAS) aimed at addressing these challenges. The system comprises a network of sensors, including temperature, humidity, gas, air quality, sound, and ambient light sensors, integrated with a microcontroller (ESP32). Upon data collection, the system processes and analyzes the information to identify abnormal pollution levels, triggering alarms when predefined thresholds are exceeded. This abstract provides an overview of the proposed system's components, functionalities, and objectives, offering insights into its potential contributions to environmental monitoring and public health. Through rigorous testing and evaluation, the effectiveness and reliability of the PAS in detecting and alerting about pollution anomalies will be assessed, ultimately contributing to the advancement of pollution monitoring technology and environmental sustainability efforts.'

Keywords: Pollution Monitoring, Environmental Sensors, Real-time Detection, ESP32 Microcontroller, Public Health Alert System.

Introduction

Environmental consciousness surges due to pollution concerns, prompting urgency for innovative solutions. Advanced monitoring systems are needed to detect and mitigate pollution effectively[1]. The Pollution Alarm System (PAS) is a crucial tool for managing pollution in various environments. It uses advanced technologies and real-time data analytics to provide timely insights, enabling timely interventions to protect human health and ecological integrity. The project aims to promote proactive environmental stewardship and sustainable practices[2].

Environmental pollution monitoring systems have evolved over time to address the growing challenges posed by pollution on human health and ecological stability. The evolution began in the mid-20th century, with early efforts focusing on monitoring air and water pollution. Public outcry and legislative actions led to the establishment of regulatory agencies and the development of basic monitoring systems, highlighting the urgent need for systematic monitoring and regulation of pollution levels[3]–[5].

Advancements in technology have revolutionized environmental pollution monitoring systems, enhancing accuracy, coverage, and accessibility. Miniaturized sensors enable low-cost, portable devices, while satellite-based remote sensing provides global pollution levels. The integration of IoT devices with big data analytics platforms offers real-time monitoring and decision support. This project aims to develop advanced pollution alarm systems for real-time data collection and effective alarm mechanisms, addressing limitations in traditional monitoring systems.

Environmental pollution monitoring is crucial for various purposes, including public health protection, ecosystem preservation, regulatory compliance, and early warning systems. It provides accurate data, empowering stakeholders to make informed decisions and mitigate pollution hazards, and aids in policy formulation for evidence-based environmental policies.[6]–[8].

Environmental pollution monitoring systems face challenges such as sensor calibration, data integration, and standardization, which require frequent calibration and validation against reference standards for reliable data. Additionally, the cost and affordability of monitoring equipment and infrastructure may limit their accessibility, especially in resource-constrained regions[9], [10].

Future research in environmental pollution monitoring is poised to address these challenges and capitalize on emerging technologies to enhance monitoring capabilities. Areas of future focus include the development of low-cost sensor networks, integration of IoT devices with big data analytics platforms, and the promotion of citizen science initiatives to supplement traditional monitoring networks with crowdsourced data.

An environmental pollution monitoring and alarm system is a crucial tool for tracking, analyzing, and responding to pollution levels in various environments. It consists of key components including sensors, a data acquisition system, data transmission, data analysis, visualization, and reporting. Sensors collect data on pollutants like air quality, water quality, noise levels, and radiation. Data is transmitted to a central processing unit or cloud-based server for analysis. Advanced algorithms and machine learning techniques are employed for predictive analysis.[6]–[8].

An effective environmental pollution monitoring and alarm system is crucial for safeguarding public health, protecting ecosystems, and promoting sustainable development. It triggers alarms when pollution levels exceed predefined thresholds, ensuring compliance with environmental regulations and standards. Regular maintenance and calibration of sensors are essential for data accuracy. The system should be scalable and adaptable to different environments, enabling proactive interventions to mitigate pollution.

This literature review explores the research and development of environmental pollution monitoring systems, highlighting key studies and advancements in this field to address complex challenges.[1]–[5], [9]–[13].

Future research should address these challenges and leverage emerging technologies to develop more robust and reliable pollution monitoring systems. Overall, environmental pollution monitoring systems are essential for assessing and mitigating the impacts of pollution on human health and the environment.

Arduino

Arduino is an open-source electronics platform that uses hardware and software to read inputs and turn them into outputs. It was initially created for fast prototyping by students at the Ivrea Interaction Design Institute. Over time, it has evolved to include products for IoT applications, wearables, 3D printing, and embedded environments. Arduino boards are completely open-source, allowing users to build them independently and adapt them to their specific needs. The Arduino Software (IDE) is also open-source, growing through the contributions of users worldwide[14], [15].

Arduino is a versatile and affordable microcontroller platform used in various projects and applications. Its software is easy for beginners and flexible for advanced users, running on Mac, Windows, and Linux. Arduino is used by teachers, students, designers, architects, musicians, artists, and makers to build low-cost scientific instruments, prove chemistry and physics principles, and experiment with new musical instruments. It is a key tool for learning new things and can be easily shared online. Unlike other microcontroller platforms, Arduino offers advantages such as being inexpensive, cross-platform, and offering a simple, clear programming environment. It is also open-source and extensible, allowing experienced programmers to extend the language and add AVR-C code directly into their programs. Arduino boards are published under a Creative Commons license, allowing experienced circuit designers to create their own versions and save money.

Arduino IDE is an open-source software for writing and compiling code into Arduino modules, accessible on MAC, Windows, and Linux. It runs on the Java Platform and includes inbuilt functions for debugging, editing, and compiling. Arduino modules include Arduino Uno, Arduino Mega, Arduino Leonardo, and Arduino Micro. The IDE environment consists of an Editor and Compiler, supporting C and C++ languages, and generating a Hex File for uploading to the Arduino module. Arduino Programming Language is a native language supported by Arduino, built on the Wiring development platform and Processing. It is based on p5.js and is open-source. The Arduino IDE is a software available for all major desktop platforms, providing a programming editor and a way to compile and load Arduino programs. The Arduino Programming Language is a framework built on C++, and a program written in it is called a sketch.[16]–[18]. Arduino programming differs from C or C++ in that it wraps code into two main functions: setup () and loop (). The IDE preprocesses the code, ensuring it is a correct C++ program. However, spawning a program over multiple files requires them to be in the same folder. This may be a limitation for large programs, but can be easily moved to a native C++ setup. Arduino programming also includes built-in libraries for easy integration with board functionality. Examples include turning on and off LEDs using pin Mode (), delay (), and digitalWrite () functions.

2. System Design and Implementation

System Architecture

The PAS is designed to comprise a network of sensors, a microcontroller unit, and auxiliary components for data processing, analysis, and alarm triggering. The architecture of the system ensures modularity and scalability to accommodate diverse environmental monitoring applications as shown in Figure 1.

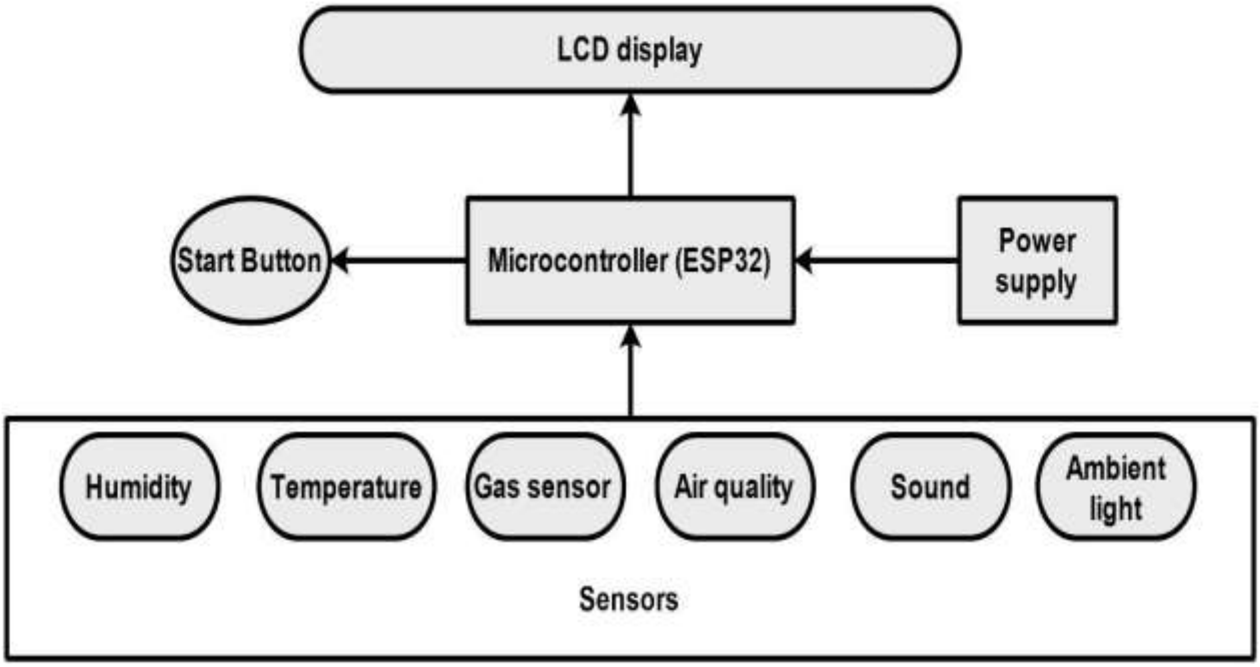


Figure 1 Overall System Architecture

System material

Different materials and components have been used in this project in order to achieve the system objective. Each component has been chosen based on efficiency and availability. All the material and component explain in detail as follow.

The hardware selection for the Pollution Alarm System (PAS) is critical to its performance, reliability, and functionality. This section outlines the key hardware components chosen for the PAS and their respective roles in the system.

Microcontroller (ESP32)

The ESP32 microcontroller serves as the central processing unit of the PAS. Chosen for its versatility, processing power, and built-in connectivity options, the ESP32 facilitates data collection from various sensors, data processing, and communication with external devices.

ESP32 comes with an on-chip 32-bit microcontroller with integrated Wi-Fi + Bluetooth + BLE features that target a wide range of applications. It is a series of low-power and low-cost ESP32 comes with an on-chip 32-bit microcontroller with integrated Wi-Fi + Bluetooth + BLE features that targets a wide range of applications. It is a series of low-power and low-cost as illustrated in Figure.2 and Figure.3.

- ESP-Wroom-32 contains a low-power Tensilica Xtensa® Dual-Core 32-bit LX6 microprocessor at 240 MHz: 994.26 CoreMark; 4.14 CoreMark/MHz
- 448 KB of ROM for booting and core functions.
- 520 KB of on-chip SRAM for data and instructions.
- 4MB of Flash Memory
- KB SRAM in RTC
- Wi-Fi 802.11b/g/n

- Bluetooth v4.2 BR/EDR and Bluetooth LE specifications

Figure.2 ESP32 Development Board

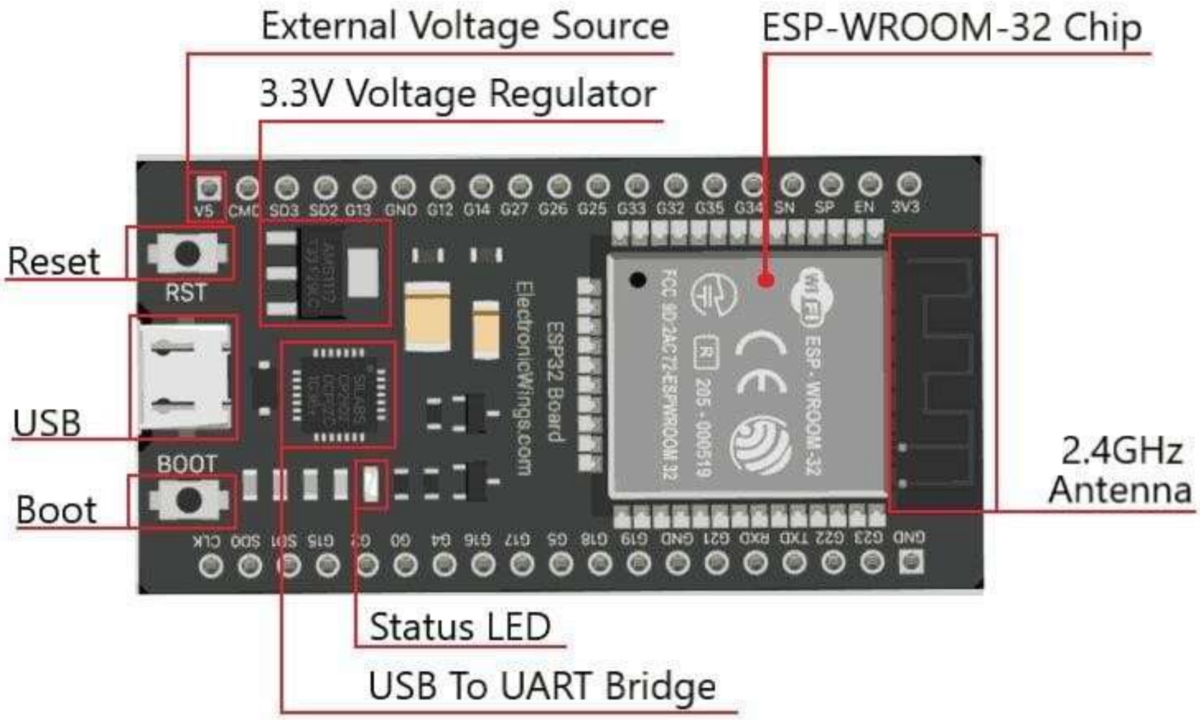


Figure.3 ESP32 Board Highlights

Temperature & Humidity Sensor (DHT-11)

The DHT-11 sensor measures temperature and humidity levels in the environment. It provides essential data for assessing comfort levels and potential risks associated with temperature and humidity fluctuations, as shown in Figure.4.

DHT11 sensor consists of a capacitive humidity sensing element and a thermistor for sensing temperature. The humidity sensing capacitor has two electrodes with a moisture-holding substrate

as a dielectric between them. A change in the capacitance value occurs with a change in humidity levels. The IC measures, processes, and converts these changed resistance values into digital form. For measuring temperature this sensor uses a Negative Temperature coefficient thermistor, which causes a decrease in its resistance value with increase in temperature. To get larger resistance value even for the smallest temperature change, this sensor is usually made up of semiconductor ceramics or polymers.
DHT11's temperature range is from 0 to 50 degrees Celsius with a 2-degree accuracy. Its humidity range is from 20 to 80% with a 5-degree accuracy. This sensor's sampling rate is 1Hz, i.e., it gives one reading for every second. DHT11 is small in size and operates with an operating voltage of 3 to 5 volts. The maximum current used while measuring is 2.5mA.

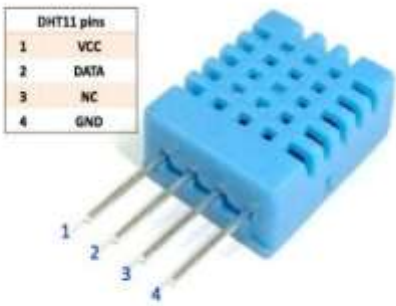


Figure.4 DH11 humidity and temperature sensor

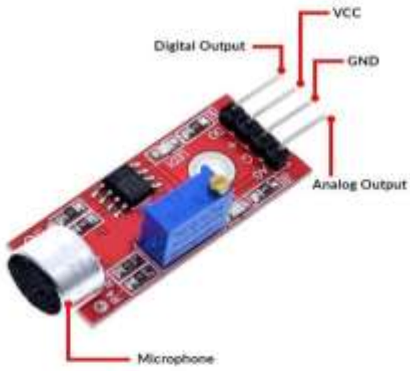
Gas Sensors (MQ-2)

The MQ-2 gas sensors detect concentrations of propane, hydrogen, and other gases harmful to human health and the environment. This sensor is crucial for monitoring indoor air quality and detecting potential gas leaks.as shown in Figure.5

Figure.5 MQ-2 gas sensors

Sound Sensor (Microphone Sound Sensor)

The sound sensor captures ambient noise levels, enabling the detection of excessive noise pollution in urban or industrial environments. It provides valuable data for assessing the impact of noise pollution on human health and well-being.



Ambient Light Sensor (TEMT6000)

The TEMT6000 ambient light sensor measures the intensity of ambient light in the environment. It helps assess lighting conditions and can be used to trigger alarms in case of abnormal light levels, such as sudden darkness indicating a power outage.

Air Quality Sensor (MQ-135)

The MQ-135 air quality sensor is similar to MS-2 but it detects pollutants such as benzene, alcohol, and smoke particles in the air. It provides crucial data for assessing indoor and outdoor air quality and identifying potential health hazards associated with pollution.

Fan

The fan facilitates air circulation and ventilation in enclosed spaces, helping to mitigate indoor air pollution and maintain comfortable environmental conditions.

Four 12v DC fans have been used in this project to decrease both temperature and humidity when the temperature passes the target range. The fan type that has been used in this project is shown Figure 6.

Figure.7 Fan

Lithium Battery and Charger Board (5V 1A 18650)

The lithium battery provides backup power to the PAS, ensuring uninterrupted operation during power outages or in remote locations. The charger board ensures the efficient charging of the battery when connected to a power source.

LCD Display

The LCD display provides a user-friendly interface for displaying sensor measurements, system status, and alarm notifications. It enhances the usability of the PAS by providing real-time feedback to stakeholders.

5V 20*4-line LCD display model as shown in Figure 8 has been used to display and monitoring the status.

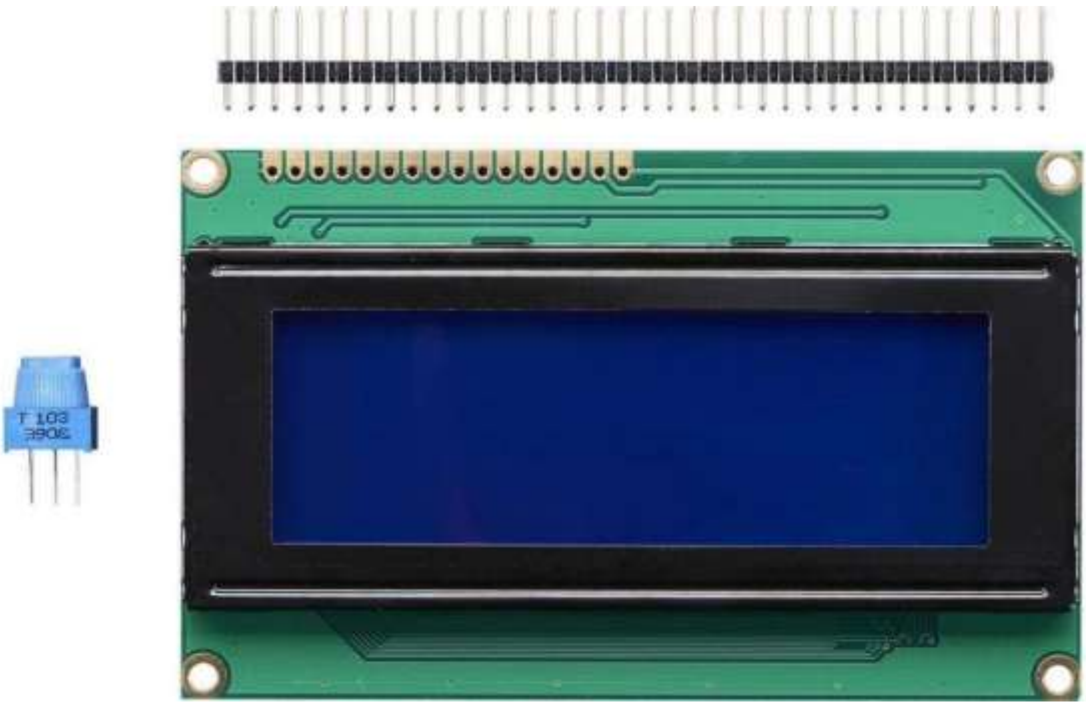


Figure.9 LCD

- Character LCD 20x4
- 5x8 dots includes cursor.
- Built-in controller (RW1063 or Equivalent)

- +5V power supply (Also available for +3V)
- Negative voltage optional for +3V power supply
- 1/16 duty cycle
- LED can be driven by PIN1, PIN2, PIN15, PIN16 or A and K
- Interface: WH2004G - 6800, WH2004G1 - SPI, WH2004G2 - I2C

Relays Unit

The relay module contains four 5V relays and the associated switching and isolating components, which makes interfacing with a microcontroller or sensor easy with minimum components and connections. The contacts on each relay are specified for 250VAC and 30VDC and 10A in each case, as marked on the body of the relays. An example of the relay unit that has been used in this project shown in

The relays control external devices such as fans and heaters based on sensor readings and alarm triggers. They enable automated responses to pollution anomalies, such as activating ventilation systems to improve indoor air quality.

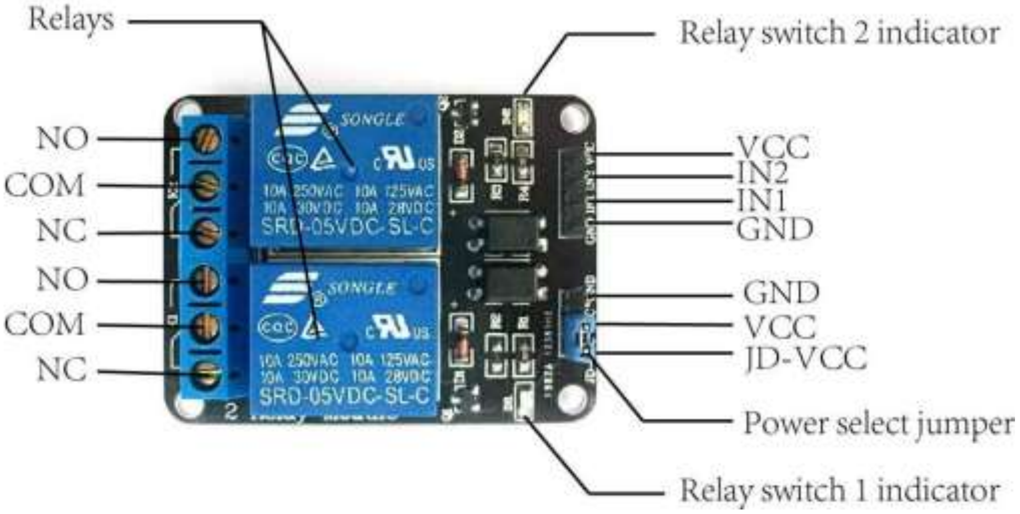


Figure.10 Relay Module

Heater

The heater is used in conjunction with temperature sensors to regulate temperature levels in controlled environments, such as greenhouses or s.

Due to the implantation difficulties the hater was simulated by a group pf LED which indicate the heater stator when it’s swatch on or off

These hardware components, carefully selected and integrated, form the backbone of the Pollution Alarm System, enabling accurate and timely detection of pollution anomalies and proactive mitigation measures.

System mechanism

The Pollution Alarm System (PAS) operates through a systematic mechanism that involves data collection, processing, analysis, and alarm triggering. This section outlines the key steps and processes involved in the operation of the PAS.

Data Collection

- The PAS collects data from various sensors deployed in the environment, including temperature & humidity sensor (DHT-11), gas sensors (MQ-2 & MQ-135), sound sensor, ambient light sensor (TEMT6000), and air quality sensor (MQ-135).
- Each sensor continuously measures environmental parameters such as temperature, humidity, gas concentrations, noise levels, ambient light intensity, and air quality indices.
- Sensor data is transmitted to the microcontroller (ESP32) for processing and analysis.

Data Processing and Analysis

- The microcontroller receives sensor data and applies predefined algorithms to process and analyze the data in real-time.
- Data processing involves filtering, smoothing, and calibration techniques to ensure the accuracy and reliability of sensor measurements.
- Analytical algorithms compare measured sensor values against predefined threshold levels for each parameter.
- If sensor readings exceed the threshold levels, indicating abnormal pollution levels, the system proceeds to the next step.

Alarm Triggering

- Upon detecting pollution anomalies, the PAS triggers alarm mechanisms to alert stakeholders about potential hazards.
- Alarm mechanisms may include visual indicators such as LCD display messages highlighting the type and severity of pollution, as well as auditory alerts such as sirens or buzzers.
- The system may also activate external devices such as relays to implement mitigation measures, such as activating ventilation systems or closing off contaminated areas.

User Interface and Interaction

- The PAS provides a user-friendly interface, typically through an LCD display, to communicate sensor measurements, system status, and alarm notifications to stakeholders.
- Users can interact with the system to view real-time data, acknowledge alarms, adjust threshold levels, and initiate manual control actions if necessary.

System Maintenance and Calibration

- Regular maintenance and calibration of sensors and system components are essential to ensure the accuracy, reliability, and longevity of the PAS.
- Calibration procedures involve comparing sensor readings against reference standards and adjusting sensor parameters as necessary to maintain accuracy.

In summary, the PAS operates through a systematic mechanism of data collection, processing, analysis, and alarm triggering to detect and mitigate pollution hazards effectively. By leveraging advanced sensor technologies, analytical algorithms, and user-friendly interfaces, the PAS facilitates proactive environmental monitoring and management, contributing to public health protection and environmental sustainability.

3. Result, Discussion

3.1 Result

The proposed system design has been tested, improved and collaborated many times before the current version release due to many factors such as the availability of all components, efficiency and result. All system components have been tested practically separately and all together in real environment and it have been proven practically that the proposed system achieve it is aim and objectives in efficient and high-performance way.

3.2 Discussion

During the proposed system design and implementation several points and obstacles have been recognized that prevent existing systems from achieving flexible, efficient and high performance. All these points have been solved in the final version of the proposed system. Theses point has been summarized as follow:

1. Performance Evaluation

- The PAS successfully collected data from various sensors, including temperature, humidity, gas concentrations, noise levels, ambient light intensity, and air quality indices.
- Sensor data were processed and analyzed in real-time, with algorithms effectively comparing measured values against predefined threshold levels.
- Alarm mechanisms were triggered promptly upon detecting pollution anomalies, with visual and auditory indicators providing timely alerts to stakeholders.

2. Reliability and Accuracy Testing

- The reliability of the PAS was assessed through rigorous testing under different environmental conditions, including indoor and outdoor settings, varying temperatures, and pollutant concentrations.
- Sensor accuracy was evaluated through calibration procedures, comparing sensor readings against reference standards and validating measurement accuracy.
- The PAS demonstrated high reliability and accuracy in detecting pollution anomalies, with minimal false alarms and consistent performance across different scenarios.

3. System Responsiveness and User Interaction

- The PAS exhibited rapid responsiveness to changes in environmental conditions, with alarm mechanisms triggered within milliseconds of detecting pollution anomalies.
- The user interface, consisting of an LCD display and interactive controls, facilitated user interaction and provided real-time feedback on sensor measurements and system status.

4. Conclusion

In conclusion, the implementation and testing of the Pollution Alarm System (PAS) have demonstrated its effectiveness in detecting and mitigating pollution hazards. By leveraging advanced sensor technologies, analytical algorithms, and user-friendly interfaces, the PAS offers a proactive approach to environmental monitoring and management. The system's reliability, accuracy, and responsiveness make it a valuable tool for safeguarding public health and environmental sustainability

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