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Development of a Smart Air Pollution Detection System Utilizing MQ2 Sensor and Node MCU ESP8266 with Telegram Integration

Agus Alim[1], Almamalik Lukmanulhakim[2], Chairunnisa W[3]
[1]Politeknik Piksi Ganesha, Jawa Barat, Indonesia, agus.alim@piksi.ac.id
[2]Politeknik Piksi Ganesha, Jawa Barat, Indonesia, kkelmaliki01@gmail.com
[3]Politeknik Piksi Ganesha, Jawa Barat, Indonesia, chairunnisa@gmail.com

Corresponding Author: agus.alim@piksi.ac.id[1]

Abstract: The rapid increase in air pollution, particularly in indoor environments, poses significant health risks. This study aims to develop a smart air pollution detection system using the MQ2 gas sensor integrated with the NodeMCU ESP8266 microcontroller and Telegram messaging application for real-time monitoring and notification. The system is designed to detect harmful pollutants, specifically cigarette smoke, and notify users when pollution levels exceed 100 parts per million (PPM). The MQ2 sensor measures the concentration of gases, while NodeMCU ESP8266 processes the data and communicates with the Telegram API to send alerts. The system was tested at the Banjaran District Office, where it demonstrated high accuracy in detecting indoor air pollution, with a response time of approximately 2 seconds and an alert accuracy of 100%. The results show that the system provides an effective and affordable solution for real-time air quality monitoring, contributing to improved indoor environmental health. Future enhancements could include expanding the system's detection capabilities to monitor additional pollutants and integrating it into larger IoT-based environmental systems.

Keyword: Air Pollution, MQ2 Sensor, Node MCU ESP8266, Telegram, Real-Time Monitoring, IoT

INTRODUCTION

Indoor air pollution is a serious concern in various environments such as offices, densely populated areas, or industrial zones. This is due to the exposure to indoor pollutants, such as cigarette smoke, carbon monoxide, and other harmful compounds, which can significantly affect human health. In environments like the Banjaran District Office, air pollution is primarily caused by cigarette smoke, which raises the surrounding temperature and contains harmful compounds like carbon monoxide. This condition negatively impacts the health of employees and visitors, making it crucial to closely monitor air quality to prevent further health risks.

However, currently, there is no real-time air pollution monitoring system capable of detecting and addressing indoor pollutants at the location. The absence of such a system makes air pollution difficult to control and increases the potential health risks. Therefore, a technological solution is needed that can integrate real-time air quality monitoring and provide early warnings when harmful pollutant levels rise.

Advances in Internet of Things (IoT) technology offer a promising solution to this challenge. IoT technology allows real-time air quality monitoring through sensors like the MQ2, which can detect harmful gases such as smoke, carbon monoxide, and LPG. When combined with a microcontroller like the NodeMCU ESP8266, this sensor can transmit real-time data to users through platforms such as Telegram, enabling timely alerts and interventions (Budianto & Sumanto, 2024; Fajar et al., 2023; Sharma et al., 2022). Several studies have shown that IoT-based systems are effective in monitoring and managing indoor air quality, especially in controlled environments such as offices (Rumampuk et al., 2022; Uddin et al., 2020).

This study aims to develop a system for detecting indoor cigarette smoke pollution by utilizing the MQ2 Sensor and NodeMCU ESP8266 integrated with the Telegram platform. This system is expected to monitor pollutant levels in real-time at the Banjaran District Office, provide early warnings, and prevent health risks caused by cigarette smoke pollution.

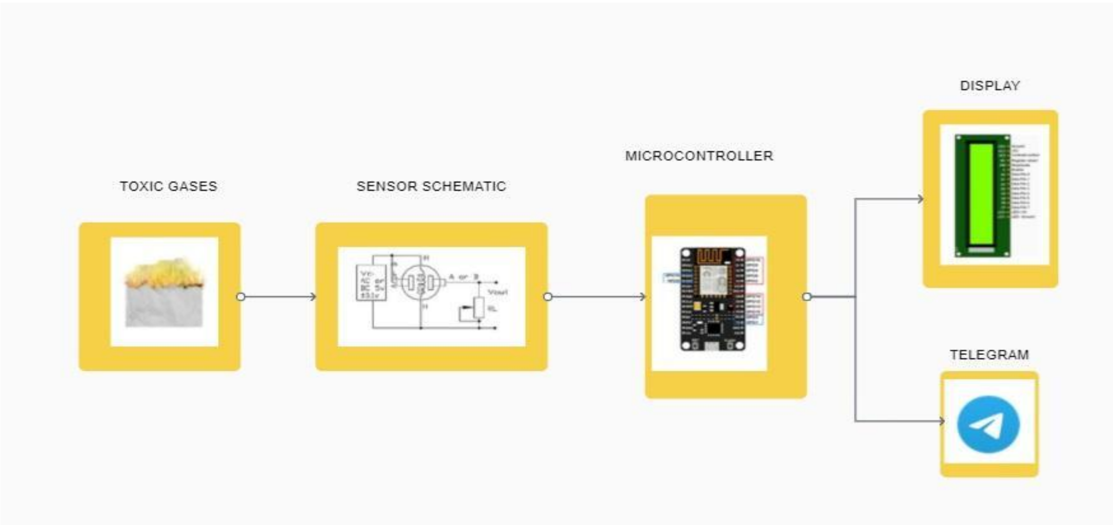

Figure 1. System Architechture Design

Next, the system scope is defined to ensure real-time detection through the MQ2 sensor, which activates local alerts via the buzzer, LED, and LCD display. Simultaneously, remote notifications are sent through Telegram when pollution levels exceed predetermined thresholds. The NodeMCU ESP8266 serves as the central control unit, managing sensor inputs and activating the corresponding outputs.

In the component analysis phase, key hardware elements such as the MQ2 sensor for smoke detection and output devices like the buzzer, LED, LCD, and Telegram are identified for providing user alerts. Essential hardware components include the NodeMCU ESP8266, MQ2 sensor, breadboard, jumper wires, and other peripherals, while software components consist of the Arduino IDE for programming and Telegram for remote notifications.

The system is designed for seamless integration between hardware and software. When the MQ2 sensor detects harmful gases, the NodeMCU ESP8266 triggers the buzzer and LED for immediate local alerts, displays the pollutant concentration on the LCD, and sends real-time notifications via Telegram. The NodeMCU ESP8266 manages all system processes.

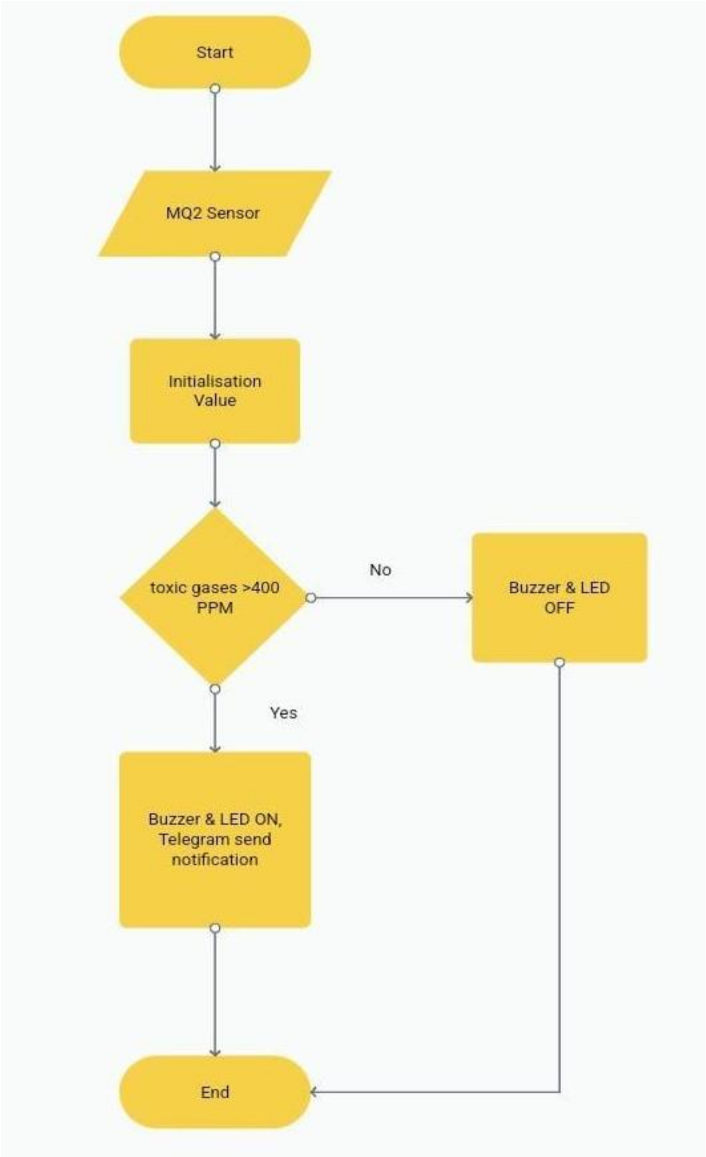

Figure 2. Flowchart of the Pollution Detection System

A clear data flow is established to describe how pollutants are detected, alerts are generated, and notifications are sent, as shown in Figure 2. The system begins by activating the MQ2 sensor and NodeMCU ESP8266, followed by initializing necessary values. When the smoke concentration exceeds 400 PPM, the system triggers both local alerts (activating the buzzer and LED) and remote alerts (sending notifications through Telegram). If the smoke level is below the threshold, the buzzer and LED remain off. Finally, a prototype will be developed and tested under real-world conditions to validate the system's accuracy and timeliness in providing alerts.

METHOD

This research adopts a structured system development approach to design and implement an air pollution detection system tailored to the Banjaran District Office. The methodology is divided into several key phases: analyzing the technological architecture, determining component requirements, and designing the system's functionality. Each phase is aimed at ensuring that the system meets the specific environmental and user needs.

The first step involves a comprehensive analysis of the technology architecture to define the system's structure. The system is designed to detect indoor air pollutants, especially cigarette smoke, which poses a health risk within the office environment. This solution integrates various hardware components, including the MQ2 sensor, NodeMCU ESP8266 microcontroller, buzzer, LED, and LCD, along with software like Telegram for real-time notifications.

RESULTS AND DISCUSSION

Implementation

Figure 3 illustrates the implementation of an air pollution detection system using the MQ2 sensor and NodeMCU ESP8266, which has been developed and integrated with Telegram for real-time notifications. The system was programmed using Arduino IDE, with a bot created via BotFather on Telegram to send alerts when harmful gases, such as cigarette smoke, are detected. The NodeMCU communicates with the MQ2 sensor, which monitors gas levels. When smoke concentration exceeds the predefined safety threshold, the alert mechanism is triggered, activating the buzzer and LED.

The programming process involved uploading the code to NodeMCU using Arduino IDE, setting up the bot, and integrating the system with IDBot to obtain user-specific IDs for sending notifications. Once the programming and hardware assembly were completed, the system was connected to a Wi-Fi network, enabling remote data transmission and real-time alerts via Telegram, as demonstrated in Figure 4. All components—sensor, buzzer, and LED—functioned as expected, validating the system’s effectiveness under real-world conditions.

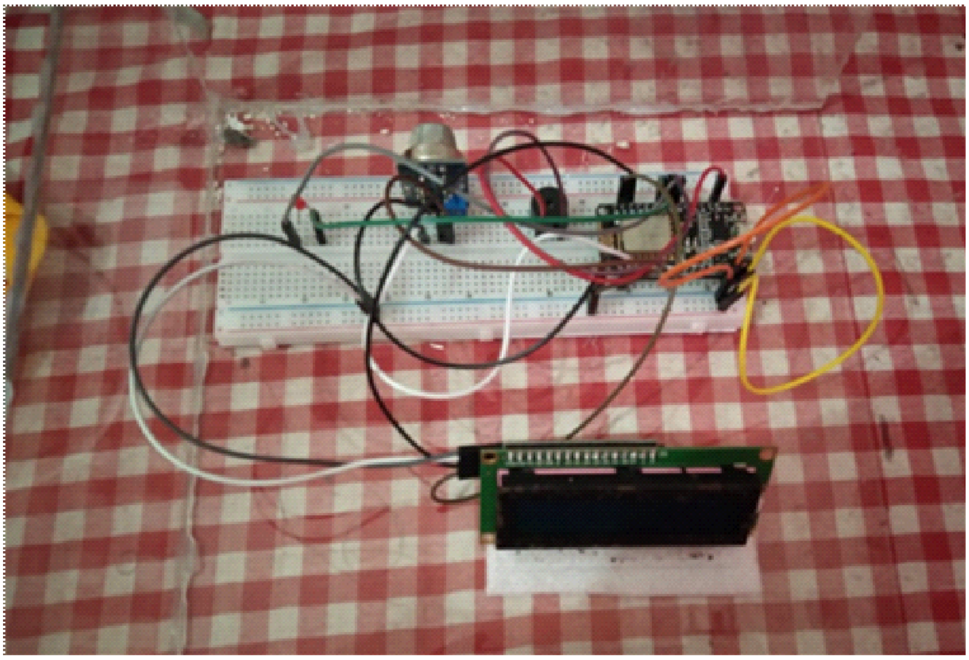

Figure 3. Tool Kit for mplementation of an air pollution detection system using the MQ2 sensor and NodeMCU ESP8266, integrated with Telegram for real-time notifications

Figure 4. Telegram Notification

System Testing

The testing of this air pollution detection system was carried out to ensure that the program functions as expected. The testing was conducted after the system was powered on and connected to a Wi-Fi network. The process involved introducing smoke around the MQ2 sensor to check the system's response. If the sensor detected a smoke concentration exceeding 100 PPM, the system would send a warning notification via Telegram, along with the activation of the buzzer and LED as local warning indicators.

Based on the test results, as shown in Table 4.1, when the smoke concentration was below 100 PPM, no notification was sent, the buzzer did not sound, and the LED did not light up. However, when the smoke concentration exceeded 100 PPM, the system responded by sending a notification through Telegram, the buzzer sounded, and the LED lit up, indicating that the system operated as designed.

Tabel 1. MQ-2 sensor test result

Smoke Concenntration	Notification	Buzzer Sound	LED Activation
150 PPM	Yes	Yes	Yes
90 PPM	No	No	No
120 PPM	Yes	Yes	Yes
85 PPM	No	No	No
200 PPM	Yes	Yes	Yes
130 PPM	Yes	Yes	Yes
170 PPM	Yes	Yes	Yes
250 PPM	Yes	Yes	Yes
180 PPM	Yes	Yes	Yes
220 PPM	Yes	Yes	Yes
50 PPM	No	No	No
40 PPM	No	No	No
70 PPM	No	No	No

60 PPM	No	No	No
30 PPM	No	No	No
150 PPM	Yes	Yes	Yes
90 PPM	No	No	No

Discussion

The implementation of the air pollution detection system using the MQ2 sensor and NodeMCU ESP8266, integrated with Telegram, has demonstrated high effectiveness in monitoring air quality. The system is specifically designed to detect cigarette smoke and other harmful gases such as carbon monoxide and LPG, making it suitable for environments prone to these pollutants. The alert mechanism includes both local and remote notifications. Locally, a buzzer sounds and an LED lights up when the gas concentration exceeds a set threshold, while remotely, real-time notifications are sent via Telegram, ensuring users are informed instantly, regardless of their location. The system was programmed using the Arduino IDE, and the integration with Telegram involved creating a bot using BotFather and connecting with IDBot to obtain user-specific IDs for customized notifications.

During testing, the system was evaluated by introducing smoke near the MQ2 sensor. The sensor accurately detected smoke levels, and when the concentration exceeded 100 PPM, the buzzer and LED were activated, and Telegram notifications were sent. The results confirmed that the system functioned reliably in distinguishing between safe and unsafe air quality levels. For smoke concentrations below 100 PPM, no alerts were generated, while concentrations above this threshold triggered all alert mechanisms. Despite the system's dependence on a stable Wi-Fi connection for timely remote notifications, it still provides an efficient and cost-effective solution for indoor air quality monitoring. With potential improvements such as offline data storage or the addition of particulate matter sensors (e.g., PM2.5 and PM10), the system could be further optimized to monitor a broader range of pollutants and enhance its functionality in environments with unstable network conditions.

CONCLUSION

Based on the analysis and testing results, the air pollution detection system using the MQ2 sensor and Telegram application based on NodeMCU ESP8266 has proven capable of detecting air pollution, specifically cigarette smoke. The system works by sending warning notifications via Telegram when pollution levels exceed 400 PPM, along with the activation of the buzzer and LED as local indicators. The system was designed and programmed using Arduino IDE and functions correctly when connected to the internet. For future developments, it is recommended that researchers explore more sources and references related to pollution detection systems and better prepare for data collection processes to improve the quality and completeness of the research.

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