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Fertigation Monitoring and Control System for Home Chili Cultivation Based on Internet of Things (IoT)

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ABSTRACT

This study developed an advanced Internet of Things (IoT)-based fertigation system aimed at optimizing growth and resource efficiency in contemporary agriculture. The system is meticulously designed by integrating various sensors that facilitate real-time monitoring of critical agronomic parameters such as soil moisture, temperature, nutrient concentrations, and tank solution levels. These sensors acquire essential data, which is processed using fuzzy logic to effectively manage irrigation control. Additionally, the system incorporates a mobile application, enabling remote monitoring and control, thus providing agricultural practitioners the convenience of managing their fields from any location. results from the study demonstrate a notable 30% increase in water use efficiency and a significant 25% improvement in crop yield compared to conventional manual irrigation techniques. This innovative fertigation system presents a comprehensive and effective solution for modern agriculture, supporting enhanced decision-making for crop management, reducing resource wastage, and augmenting overall agricultural productivity, thereby contributing to sustainable farming practices.

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1. INTRODUCTION

The cultivation of chili peppers is a highly favored activity among Indonesians, and Indonesia is one of the largest consumers of chili peppers globally[1], Chili peppers are considered a vital food product in Indonesia, even influencing inflation rates[2]. he popularity of chili peppers in traditional Indonesian cuisine encourages many people to cultivate them at home. One alternative for home cultivation is using polybags in home gardens [3].

Chili pepper cultivation requires special attention, particularly in watering and fertilization. The availability of adequate water and nutrients significantly affects the growth and productivity of chili pepper plants[4]. peppers thrive in humus-rich, fertile, and loose soil with an ideal temperature of 24-30°C°[5]. However, the main challenge in home cultivation of chili peppers is maintaining consistent optimal care. These plants are susceptible to overly wet soil conditions, which can increase the risk of pests and diseases [6].

Given the importance of consistent care, an effective and efficient mechanism to regulate the flow of liquid fertilizer and water is required, especially for cultivation in limited spaces. One effective solution is the use of a fertigation system[7]. Previous research tested the performance of a drip fertigation control system on tomato plants, incorporating a notification concept for users during irrigation alarms, post-irrigation, and when water supplies are low[8] This study demonstrated that the developed drip fertigation system achieved excellent fertigation coefficients, serving as a benchmark for the feasibility of such systems.

To optimize chili pepper cultivation, the authors developed an IoT-based automatic drip fertigation system suitable for growing chili peppers in limited home garden spaces. This system automates nutrient and water irrigation delivery and allows real-time monitoring through an Android application. This facilitates monitoring of plant conditions and optimizes chili pepper yields in small garden spaces, aiming to promote the use of appropriate technology in small-scale agriculture.

2. RESEARCH METHOD

This study developed an IoT-based fertigation monitoring and control mechanism for home-grown chili plants. The first stage involved designing hardware to facilitate the delivery and irrigation of water and nutrients. The hardware design includes monitoring soil moisture, ambient temperature, nutrient concentration in the solution, and measuring water levels in the tank. The Arduino IDE software was used to process data, display sensor readings, and transmit data to the application [9]. The processed data is then sent to the Thing Speaks server to monitor the condition of the chili plants.

2.1 Hardware Design

To optimize the planning objectives, the hardware design begins with the creation of a circuit diagram. This study includes a schematic design of the component circuitry for the device to be developed.

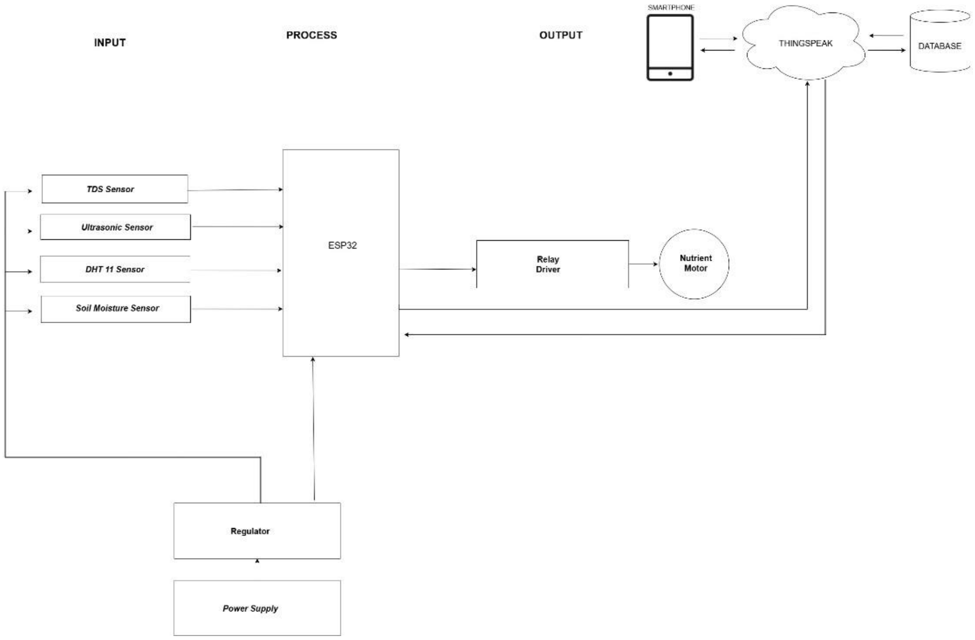

Figure 1. Block Diagram

The diagram illustrates the fertigation monitoring system for home-grown chili plants using sensors, a microcontroller, and a server, organized into input, process, and output stages. Four sensors are connected to the microcontroller, including a TDS sensor to measure the concentration of nutrients dissolved in the water [10], An ultrasonic sensor measures the water volume in the nutrient tank, a DHT11 sensor measures the ambient temperature and humidity around the chili plants, and a soil moisture sensor measures the moisture level in the growing medium. The processing section on the NodeMCU ESP32 microcontroller handles the data obtained from the sensors. After processing, the ESP32 sends the data to the ThingSpeak server, which then transmits it to the output. The output includes a water pump and drip emitter. The data sent to the ThingSpeak server provides monitoring and analysis of the chili plant conditions, with the results displayed on an Android application platform [11]. This system enables real-time monitoring capability.

2.2 Circuit Schematic

The circuit diagram is needed to identify the components and sensors used in the fertigation monitoring system for homegrown chili plants. Hardware design involves the process of creating the circuit layout for all device components, ensuring that the device functions effectively as a monitoring tool [12].

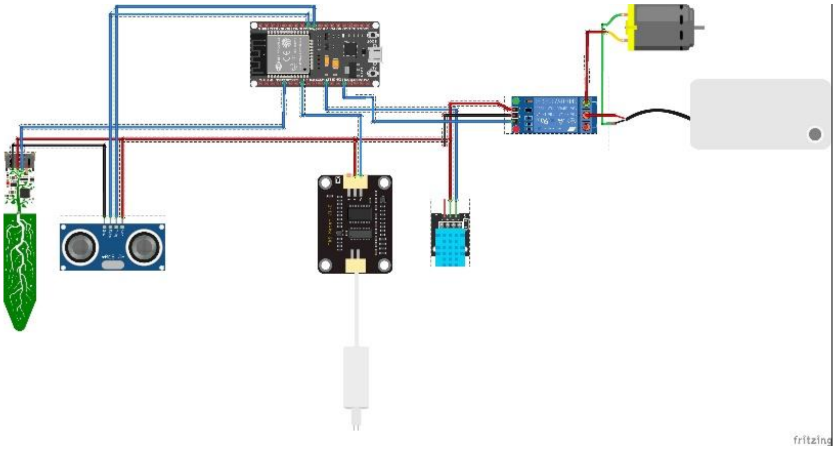

Figure 2. Wiring Diagram of System

The device schematic design explanation is as follows: The power source originates directly from the electrical supply connected to the ESP32. The ESP32 provides 5 volts of power to all connected sensors, acting as the main microcontroller. An ultrasonic sensor connected to pins G18 and G5 measures the nutrient solution level in the tank. A soil moisture sensor connected to pin G34 monitors water levels in the growing medium. A Total Dissolved Solids (TDS) sensor linked to pin G33 measures nutrient concentration in the solution. A DHT11 sensor connected to pin G14 monitors air temperature and humidity around the chili plants. The system includes a relay connected to pin G13, which controls the water pump and nutrient solution mixer. Data from all sensors is transmitted by the ESP32 to the ThingSpeaks server. ThingSpeaks processes this data and displays results through an Android-based monitoring application. This setup enables users to easily monitor and control the fertigation system remotely and in real-time. The wiring diagram of the system illustrates how components are connected to each other and to the microcontroller. It visually represents the physical layout and connections, ensuring clarity in the assembly and operation of the system components.

2.3 Software Design

After designing the hardware, the next stage involves designing the software, which is a crucial step guiding the program's creation. When using the Arduino IDE to develop the program, it will be uploaded to the microcontroller to ensure proper functionality and alignment. Figure 3 illustrates the flowchart of the software design process.

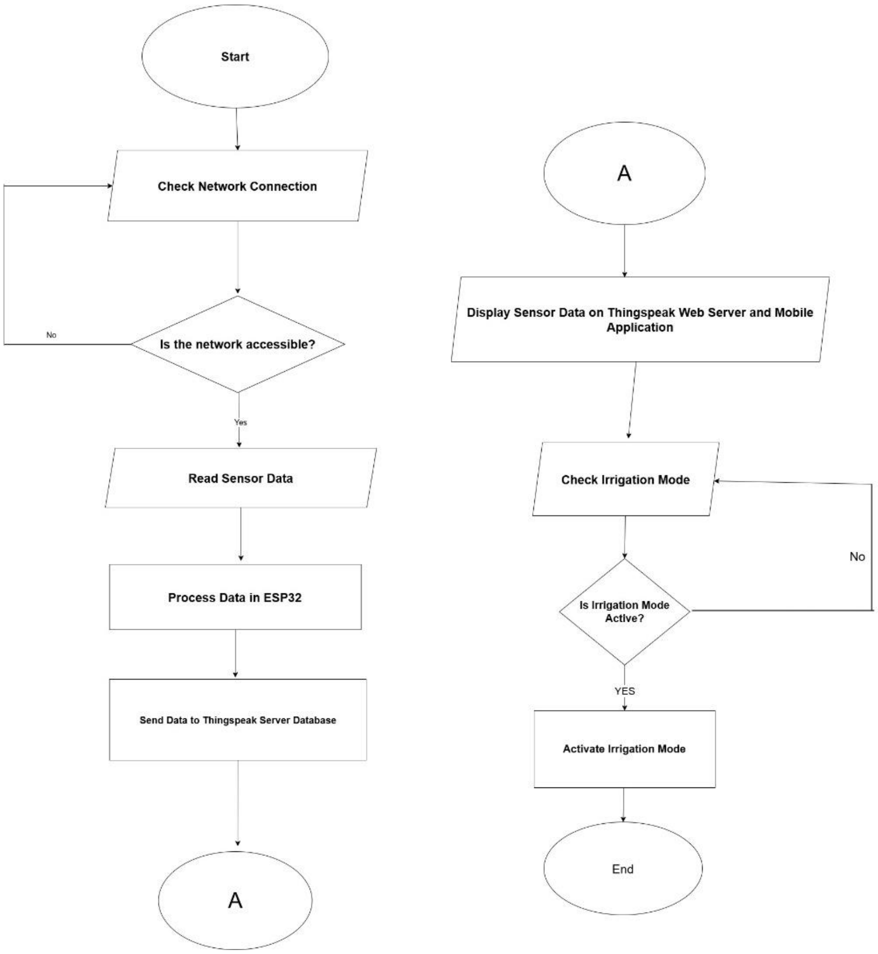

Figure 3. Flowchart of Software design system

The software flowchart illustrates the working process of the fertigation system. The main steps are as follows:

1) Start
2) The system reads sensor data, which has been programmed using the Arduino IDE software.
3) The ESP32 processes the acquired data after establishing an internet connection. If the connection fails, the ESP32 will continuously attempt to reconnect until a stable network is available.
4) Once connected, the data is stored in the Thingspeak server database.

5) The recorded sensor data is then displayed on the monitoring application and the Thingspeak web server.

In the development of a fertigation monitoring and control system, user interaction plays a crucial role. Users gain access to the application upon completing the installation process. Once successfully installed, users can log into the system, navigate the main interface, and monitor chili plant conditions in real time.

The sensor measurement data is continuously transmitted to the Thingspeak system, where it is processed and visualized through the fertigation system monitoring application. Users can conveniently assess the condition of chili plants detected by the system. All relevant information is retrieved directly from the database, ensuring accurate and up-to-date data representation.

This implementation enhances precision agriculture, allowing users to make data-driven decisions regarding irrigation and nutrient distribution, ultimately optimizing plant growth and resource efficiency.

3. RESULTS AND DISCUSSION

3.1. Hardware Design Results

This system begins with the design of an IoT-based fertigation system. This process involves assembling hardware and designing software. In the hardware assembly stage, various components are arranged to form a monitoring system consisting of a soil moisture sensor for measuring soil humidity, a DHT11 sensor for measuring environmental temperature around chili plants, a TDS sensor for measuring nutrient solution concentration, and an ultrasonic sensor for measuring solution levels in the tank. Data from each sensor will be processed by the ESP32 and NodeMCU microcontrollers. This device can be seen in Figure 7..

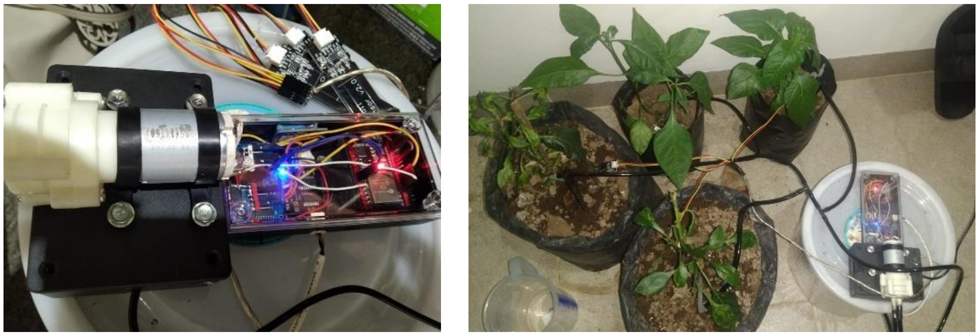

Figure 4. IoT Fertigation System Tool

In the software programming, the sensors are designed using the Arduino IDE. The NodeMCU is equipped with a built-in Wi-Fi module, enabling data transmission to the server and real-time monitoring via the web using the ThingSpeak server..[16]

3.2. Mobile Application Display

In the study, an Android application is used to monitor the real-time condition of chili plants. The Android application development leverages the MIT App Inventor software. MIT App Inventor is a web-based, open-source platform for developing Android applications [17]. This platform utilizes a graphical interface with drag-and-drop methods and block-based programming[18]. Below is an image of the Android application used for monitoring the condition of chili plants.

Nutrisi : 1007
Tanki : 2
Suhu : 30
Kelembapan : 66
status: lakukan penyiraman

Nutrisi : 996
Tanki : 3
Suhu : 30
Kelembapan : 75
status: penyiraman cukup

Figure 5. Fertigation System Mobile Application

There are two switch buttons in the application, which are connected to the water pump. They function to turn the water pump on and off, controlling the flow of water. The mobile application features four gauges: the first gauge monitors the total dissolved solids (TDS), the second gauge monitors the solution level in the tank, the third gauge monitors the temperature around the plants, and the last gauge monitors the humidity level of the chili plants. Monitoring these factors ensures optimal growth of the chili plants.

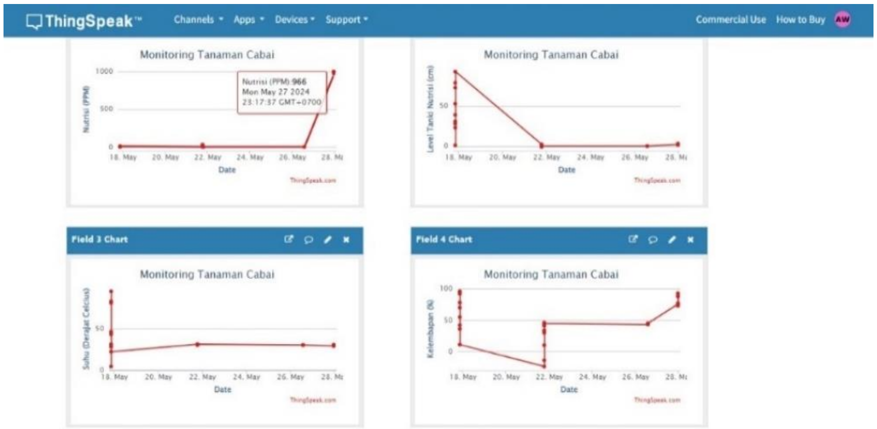

Figure 6. ThingSpeaks web server monitoring results

The image above depicts the stored data results saved on the ThingSpeak web server. The data is displayed using various visualizations such as curves, status indicators, and histograms, enabling real-time monitoring of chili plant conditions. This setup also allows for data storage[19][20]. The image above depicts the stored data results saved on the ThingSpeak web server. The data is displayed using various visualizations such as curves, status indicators, and histograms, enabling real-time monitoring of chili plant conditions. This setup also allows for data storage [19][20]. The author utilizes Excel for storing data to facilitate the data collection process.

3.3. Test Resultz

3.3.1. System Testing Results

The IoT-based fertigation system was tested over a period of 20 days, with data collection conducted every three days. Irrigation was carried out using the drip method to maintain optimal soil moisture. The system triggered irrigation when soil moisture dropped below 76% and stopped when it exceeded 80%. Throughout the testing period, the recorded soil temperature ranged between 28–30°C, which falls within the ideal range for chili plant growth. Meanwhile, the TDS (nutrient concentration) remained between 900–1015 ppm, indicating a stable nutrient supply for the plants.The data obtained is presented in Table 2.

Table 1. Tool Test Results

No	Date	Temperature (°C)	Soil Moisture (%)	TDS (PPM)	Note
1.	**27 May**	**28.5**	**96**	941	**Sufficient**
2.	**30 May**	**29.0**	**80**	901	Sufficient

3.	**2 June**	**30.2**	**64**	**1007**	Irrigation Needed
4.	**5 June**	**27.8**	**76**	**995**	Irrigation Needed
5.	**8 June**	**29.5**	**99**	970	Sufficient
6.	**11 June**	**31.0**	**77**	**1009**	Irrigation Needed
7.	**14 June**	**28.0**	**73**	**1009**	Irrigation Needed
8.	**18 June**	**29.8**	**82**	997	Sufficient
9.	**22 June**	**30.5**	**95**	983	Sufficient

The results indicate that the system effectively maintained soil moisture within the optimal range. The average irrigation duration was approximately 5–10 minutes per session, conducted once a day, either in the morning or evening, depending on environmental conditions. Morning irrigation helped reduce soil temperature and prevent excessive evaporation, while evening irrigation prevented dryness at night.

3.3.2. Data Collection Results

Plant growth evaluation was conducted by measuring plant height and leaf count at the beginning and end of the study period. On the first day, the chili plants had an average height of approximately 10 cm with two to four leaves per plant. By the end of the 20-day observation period, the plants had grown to an average height of 15 cm with eight leaves. This increase in height and foliage suggests that the fertigation system provided sufficient water and nutrients for optimal plant development.

Table 2. Final collection results

Date	Plant Height	Leaf Count	Plant Condition
1	**10 cm**	**2**	Healthy
20	**15 cm**	**8**	Healthy but slightly unstable

Figure 7 Comparison of Initial and Final Growth of Chili Plant

The results highlight a noticeable improvement in plant growth, particularly in terms of leaf development, which plays a crucial role in photosynthesis and overall plant health.

4. CONCLUSION

The implementation of a monitoring and control system for irrigation and fertilization in homegrown chili plants can enhance efficiency. During a 20-day testing period, the fertigation system demonstrated a positive impact on the growth and health of chili plants. The plant height increased from an initial range of 10-12 cm per plant on the first day to 15 cm. Meanwhile, the average number of leaves per plant increased from 2 to 8 leaves.

The application of IoT-based technology can effectively assist in real-time monitoring of chili plant environmental conditions from anywhere and at any time, ensuring that the growing medium remains in optimal conditions. During testing, soil moisture was maintained at approximately 80%, with an average temperature of 29°C, which supports the ideal conditions for chili plants. The nutrient concentration, measured using a TDS sensor, ranged between 900-1015 ppm.

REFERENCES

[1] J. A. Pratiwi, A. D. Susila, and K. Suketi, “Respon Tanaman Cabai Rawit (Capsicum frustescens L.) pada Sistem Irigasi Tetes Terhadap Aplikasi Nanosilika lewat Daun,” *Bul. Agrohorti*, vol. 10, no. 3, pp. 360–368, 2023, doi: 10.29244/agrob.v10i3.46447.

[2] A. Fauzi *et al.*, “Pengaruh Meningkatnya Harga Cabai Terhadap Permintaan Dan Penawaran Di Indonesia,” 2023.

[3] E. M. Al Khaafidh, F. Astuti, A. Anggun, J. Apriliani, and M. Marini, “Budidaya Tanaman Cabe Rawit Dipolibeg,” *J. Ilm. Mhs. Kuliah Kerja Nyata*, vol. 2, no. 3, pp. 630–636, 2022, doi: 10.36085/jimakukerta.v2i3.4079.

[4] N. Finahari, K. P. Budi, and T. D. Putra, “Potensi Sprayer Otomatis sebagai Solusi Masalah Penyiraman Tanaman untuk Petani Cabe,” *JATI EMAS (Jurnal Apl. Tek. dan Pengabdi. Masyarakat)*, vol. 3, no. 1, p. 19, 2019, doi: 10.36339/je.v3i1.184.

[5] J. Konstitusi *et al.*, “Budidaya Tanaman Sayuran,” *Angew. Chemie Int. Ed. 6(11), 951–952.*, vol. 3, no. 2, p. 1, 1967, [Online]. Available: https://www.neliti.com/id/publications/218225/kemajuan-teknologi-informasi-dan-komunikasi-dalam-industri-media-di-indonesia%0Ahttp://leip.or.id/wp-content/uploads/2015/10/Della-Liza_Demokrasi-Deliberatif-dalam-Proses-Pembentukan-Undang-Undang-di-Indonesia

[6] M. G. M. Polii, T. D. Sondakh, J. S. M. Raintung, B. Doodoh, and T. Titah, “Kajian Teknik Budidaya Tanaman Cabai (Capsicum annuum L .) Kabupaten Minahasa Tenggara,” *Eugenia*, vol. 25, no. 3, pp. 73–77, 2019.

[7] B. Lanya, P. A. Laksono, M. Amin, and R. Zahab, “Rancang Bangun Sistem Fertigasi Dengan

Menggunakan Venturimeter," *J. Tek. Pertan. Lampung (Journal Agric. Eng.*, vol. 9, no. 2, p. 122, 2020, doi: 10.23960/jtep-l.v9i2.122-130.

[8] I. H. Rosma, D. Y. Sukma, and I. M. Solihin, "Otomatisasi Sistem Fertigasi Tetes untuk Tanaman Berbasis Mikrokontroler," *J. Tek. Elektro*, vol. 13, no. 1, pp. 34–41, Oct. 2021, doi: 10.15294/jte.v13i1.31123.

[9] J. Jtik, J. Teknologi, A. Herlan, I. Fitri, and R. Nuraini, "Rancang Bangun Sistem Monitoring Data Sebaran Covid-19 Secara Real-Time menggunakan Arduino Berbasis Internet of Things (IoT)," vol. 5, no. 2, 2021.

[10] Y. Irawan, A. Febriani, R. Wahyuni, and Y. Devis, "Water Quality Measurement and Filtering Tools Using Arduino Uno , PH Sensor and TDS Meter Sensor," vol. 2, no. 5, 2021, doi: 10.18196/jrc.25107.

[11] M. Walid, A. Fikri, T. Informatika, U. Islam, S. Informasi, and U. Islam, "Pengembangan Sistem Irigasi Pertanian Berbasis Internet Of," vol. 5, no. 1, pp. 31–38, 2022.

[12] P. Studi, S. Komputer, U. Pembangunan, and P. Budi, "Perancangan Smart Home dengan Konsep Internet of Things (IoT) Berbasis Smartphone," no. x, 2016.

[13] A. M. A. P. Jaya, "Metode Fuzzy Mamdani," pp. 106–112.

[14] H. T. Sigit, I. Fernando, and T. L. Putra, "Implementasi Fuzzy Inference System Metode Tsukamoto Untuk," 2015.

[15] I. Sari, P. Pratama, and M. Z. Agung, "Temperature and Humidity Control System with Long Range in Mushroom Barn Using Fuzzy Logic," vol. 16, no. 2, 2023.

[16] C. W. Darmawan *et al.*, "Implementasi Internet of Things pada Monitoring Kecepatan Kendaraan Bermotor," vol. 9, no. 2, 2020.

[17] A. Agatha, "Utilization of MQTT and Radio GPS in Pet Monitoring," vol. 17, no. 1, 2024.

[18] M. W. Sari, "Implementasi Aplikasi Monitoring Pengendalian Pintu Gerbang Rumah Menggunakan App Inventor Berbasis Android," no. 1.

[19] S. Pasha, "Thingspeak Based Sensing and Monitoring System for IoT with Matlab Analysis," no. 6, pp. 19–23, 2020.

[20] A. D. Ramadhani, A. Nurcahya, N. Azizah, and N. Ningsih, "Klasifikasi dan Monitoring Kualitas Udara Dalam Ruangan menggunakan Thingspeak," vol. 10, no. 1, 2023.