G-Tech : Jurnal Teknologi Terapan
Vol. 9, No. 4, October 2025, p. 2132-2140
E-ISSN: 2623-064X | P-ISSN: 2580-8737

Optimizing Water Quality in Carp Farming through an IoT-based Dissolved Oxygen Monitoring System

Khusnul Hayati[1], Faishal Arham Pratikno[2], Putri Gesan Prabawa Anwar[3], Healty Susantiningdyah[4]

[1, 4] Industrial Engineering, Faculty Rekatasa Industri, Institut Teknlogi Kalimantan, Indonesia
[2, 3] logistics engineering, Faculty Rekayasa Industri, Institut Teknlogi Kalimantan, Indonesia

✉ **Corresponding Author :** Putri Gesan Prabawa Anwar (e-mail: putri.gesan@lecturer.itk.ac.id)

Article Information

Article History

Received : September 18, 2025
Revised : October 11, 2025
Published : October 26, 2025

***Keywords*:**
Blynk;
Common Carp;
Dissolved Oxygen;
Internet of Things;
Water Quality Monitoring

ABSTRACT

Dissolved oxygen (DO) is a critical parameter in common Carp (*Cyprinus carpio*) aquaculture, as low DO levels can cause stress, inhibit growth, and lead to fish mortality. Conventional measurement methods, such as manual titration or DO meters, are limited because they cannot provide continuous or real-time monitoring. Therefore, this study aims to develop an Internet of Things (IoT)-based dissolved oxygen monitoring system using the Waterfall development method to maintain optimal water quality in carp ponds. The system utilizes an ESP32 microcontroller, a DO sensor, and the Blynk platform as a real-time remote monitoring interface. It continuously measures DO levels, displays data locally on an LCD, and sends automatic notifications when the DO value falls below 5 mg/L. Field testing was conducted for one week at the Rama Graha carp pond, showing that the system achieved an accuracy of 92.7%, an error rate of 7.3%, and a precision of 98%. The developed system effectively supports farmers in maintaining stable water quality and reducing fish mortality. This study contributes to the development of practical, low-cost IoT technology for sustainable freshwater aquaculture management.

INTRODUCTION

Carp (*Cyprinus carpio*) is one of the freshwater fishery commodities with high consumption and economic value in Indonesia. Based on data from the Directorate General of Aquaculture, national carp production continues to increase every year, with total production in East Kalimantan Province in 2020 reaching 15,139 tons. The advantages of carp include rapid growth, ease of maintenance, and affordable prices, making it the primary choice in freshwater fish farming (Akbarurrasyid et al., 2020). However, the success of carp farming is highly dependent on the stability of water quality, which affects fish health and productivity. Good quality water is water that meets the needs of fish without causing adverse effects on growth, egg hatching, or survival (Syarifudin, 2016), particularly in maintaining adequate levels of dissolved oxygen (DO). Low DO levels can cause stress, lower immunity, and at critical levels may result in mass mortality (Pane et al., 2023). According to the Indonesian National Standard (SNI, 1999), the minimum DO concentration required for carp farming is 5 mg/L. Initial observations at the Rama Graha Carp Pond indicated that DO levels ranged only between 2.0 and 2.3 mg/L, far below the recommended threshold, even though other parameters such as temperature (27°C) and pH (7) remained within optimal ranges. This condition may lead to decreased productivity and financial losses.

Several conventional methods have been used to measure dissolved oxygen levels, such as the iodometric titration (Winkler) method and membrane electrode-based DO meters. However, these methods have limitations in terms of time, continuity, and real-time monitoring capability, resulting in delayed decision-making that can threaten fish survival (Septiawan et al., 2014). The Internet of Things (IoT) provides a promising framework for overcoming these limitations by enabling real-time, automated, and remote monitoring of environmental parameters (Susanto et al., 2022). Previous studies, such as Ningsih & Pratama (2022), have developed IoT-based water quality monitoring systems capable of sending data automatically and providing notifications when parameters exceed safe limits. However, most existing systems are still general in scope, focusing on overall water quality parameters without specialized monitoring of dissolved oxygen levels for carp ponds. Moreover, previous designs often lack local data display features and real-time digital notifications integrated within a single platform.

Therefore, this research aims to fill this gap by developing an IoT-based dissolved oxygen monitoring system specifically designed for carp farming, equipped with both local LCD display and real-time mobile notifications via the Blynk platform. This system enables continuous monitoring, early warning alerts, and faster response to oxygen fluctuations. The main contribution of this study lies in combining real-time monitoring, local display, and automatic notification features into a single integrated system, providing a practical and low-cost solution for small- and medium-scale aquaculture.

RESEARCH METHODS

This study uses a device engineering approach based on the Waterfall method, which is a sequential and systematic system development method. The Waterfall model has the main characteristic of continuous stages, where each stage must be completed before proceeding to the next stage (Pieters, 2025). The stages in the Waterfall model used in this study consist of 5 stages as illustrated in Figure 1.

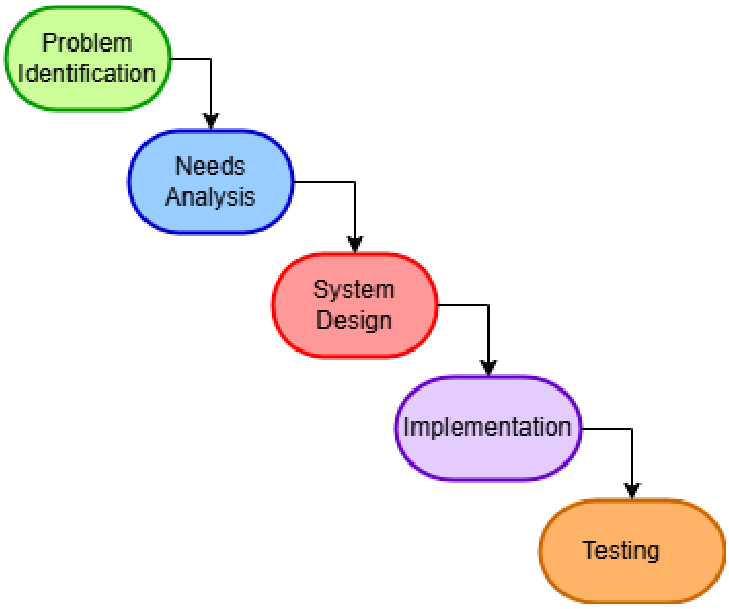

Figure 1 Waterfall Model
Source: Hayati, 2025

The first stage is problem identification. This study identifies the problems faced by carp farmers in maintaining water quality, particularly related to fluctuations in dissolved oxygen levels in ponds. Based on observations at the research site, it was found that the dissolved oxygen levels in carp ponds had an average value of 2.1 mg/L. This figure is far below the minimum standard set by the Indonesian National Standard (SNI), which is 5 mg/L. This condition indicates that the oxygen quality in the water is at a critical level that can directly affect fish health and productivity. Until now, monitoring has been carried out manually with simple tools, which are inaccurate, discontinuous, and do not allow for early detection. The next stage is a needs analysis aimed at determining the hardware and software required to build an Internet of Things-based automatic dissolved oxygen level monitoring system. The detailed hardware and software components used in this study are presented in Table 1.

Table 1. Hardware and Software Specifications of IoT-Based DO Monitoring System for Carp Pond at Rama Graha (2025)

No	Componen	Specification	Function
1	Microcontroller (ESP32)	Dual-core 32-bit processor, 240 MHz, Wi-Fi 802.11 b/g/n, Bluetooth 4.2, Operating Voltage: 3.3V	Main control unit for data processing and communication
2	Dissolved Oxygen (Analog)	Range: 0–20 mg/L, Output: 0–3.3V, Accuracy: ±0.2 mg/L	Measures dissolved oxygen concentration in pond water
3	LCD Display 16 x 2 I2C	Operating voltage: 5V, Interface: I2C	Displays DO data locally
4	Power Bank	10,000 mAh, Output 5V/2A	Provides portable power source
5	Blynk IoT Platform	Mobile & web-based monitoring app	Displays real-time data and sends notifications
6	Software Tools	Arduino IDE, Blynk App	Programming and interface setup

Source : Hayati, 2025

The system design stage includes the design of the hardware architecture and software logic. The system scheme is designed so that all components are interconnected and capable of operating automatically. The Dissolved Oxygen Sensor is connected to the ESP32, which processes the signal and displays it on the LCD, as well as sending it to Blynk via the internet. The Blynk interface is designed using the Value Display widget to display the dissolved oxygen level. The system design also includes a wiring diagram, block diagram, and an algorithm for converting the sensor signal into mg/L units. After the system design was completed, the implementation stage was carried out through the process of assembling components and programming the microcontroller using Arduino IDE. Libraries such as LiquidCrystal_I2C.h and BlynkSimpleEsp32.h were integrated to ensure stable communication between the sensor, LCD, and Blynk. The system was then tested in a cultivation pond to evaluate its performance under real field conditions.

The final stage was testing and evaluation, which aimed to assess the accuracy, precision, and reliability of the developed IoT-based dissolved oxygen (DO) monitoring system. The testing involved comparing DO readings from the system (Xi) with those from a calibrated manual DO meter (Yi) every hour for seven consecutive days. The relative error and accuracy for each measurement were calculated using the following equations:

$$\mathbf{E(\%)} = \frac{Yi-Xi}{Yi}\ x\ 100\% \qquad (1)$$

$$\mathbf{(A\%)} = 100\% - \mathrm{E}(\%) \qquad (2)$$

The results showed that the system achieved an average accuracy of 92.7% and an average error of 7.3%, indicating that the system performed reliably under dynamic pond conditions. To assess measurement stability, a precision test was also conducted by performing ten repeated measurements on the same water sample. Precision (PPP) was calculated as:

$$\mathbf{P(\%)} = 1 - \frac{S}{\bar{x}}\ x\ 100\% \qquad (3)$$

where $\bar{x}$ is the mean of repeated measurements and S is the standard deviation, calculated using:

$$S = \sqrt{\frac{1}{n-1}}\ \sum_{i-1}^{n}(Xi - X^2) \qquad (4)$$

Based on the test results, the sensor achieved a precision of 98%, confirming that the readings were consistent and reproducible.

Additionally, the system's data transmission to the Blynk platform was evaluated for reliability. The transmission success rate was calculated as the percentage of successful data packets received by the Blynk application out of the total expected transmissions during the 7-day test. The system maintained a data transmission success rate of over 95%, demonstrating stable performance in an outdoor aquaculture environment. Overall, the developed IoT-based DO monitoring system has proven to be accurate, precise, and stable, making it suitable for practical application in real-time aquaculture water quality monitoring.

RESULTS AND DISCUSSION

This study developed an Internet of Things-based dissolved oxygen level monitoring system using an ESP32 microcontroller, analog DO sensor, 16x2 LCD with I2C module, and Blynk platform as a real-time remote monitoring interface. This system aims to monitor dissolved oxygen levels in carp ponds, which, based on field observations and interviews with fish farmers at the research site, are the main cause of high fish mortality rates. Initial measurements of dissolved oxygen levels showed an average value of 2.1 mg/L, far below the minimum SNI standard of 5 mg/L. This reinforces the need for a monitoring system capable of continuously monitoring dissolved oxygen levels and providing automatic early warnings.

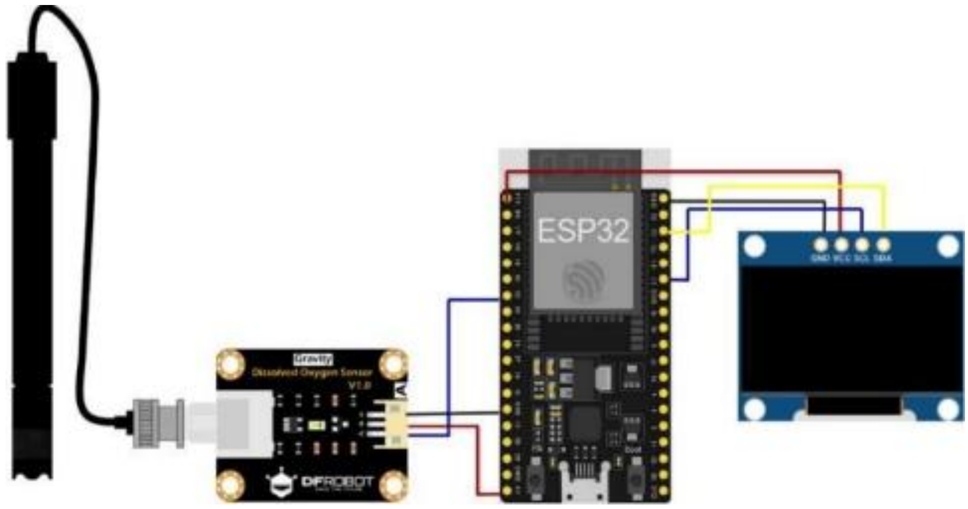

Figure 2. Schematic Diagram

Figure 2 shows a schematic diagram of the system connecting the ESP32 with the DO sensor and I2C LCD, designed on a modular breadboard. The DO sensor is connected to the ESP32 analog pin to read the voltage representing the oxygen level in ppm. The sensor reading data is processed by the ESP32 and displayed locally on the LCD, as well as sent periodically every hour to the Blynk platform via the built-in Wi-Fi connection. The ESP32 microcontroller was chosen because it is efficient in power consumption, has integrated Wi-Fi connectivity, and supports the development of Internet of Things-based systems well.

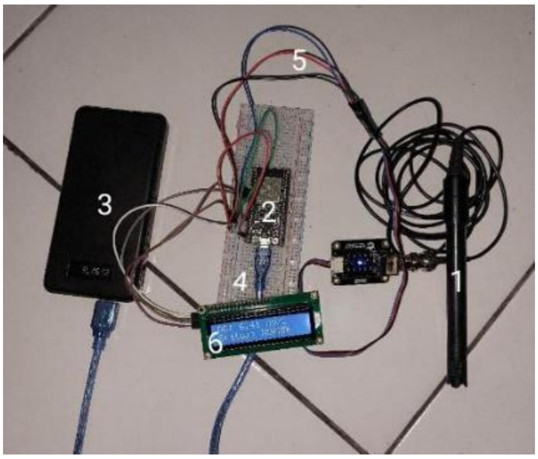

Figure 3. Monitoring System Prototype

Figure 3 shows the physical design of the system after assembly, which consists of a DO sensor that will be submerged in pond water to detect the level of dissolved oxygen in the water. The level of dissolved oxygen greatly affects water quality, both physically, chemically, and biologically (Darmayani et al., 2023). The ESP32 microcontroller is integrated with WiFi 802.11 b/g/n, Bluetooth version 4.2, and various other peripherals. The ESP32 chip is a complete package that includes a processor, storage, and access to GPIO (General Purpose Input Output) (Wagyana, 2019). LCD, and other supporting components. This system was assembled using a breadboard for ease of initial testing and powered by a 10,000 mAh power bank to ensure the system could operate without a fixed power source. The Blynk platform displays DO data through the Value Display widget. This system also features automatic notifications if the dissolved oxygen level falls below a predetermined threshold.

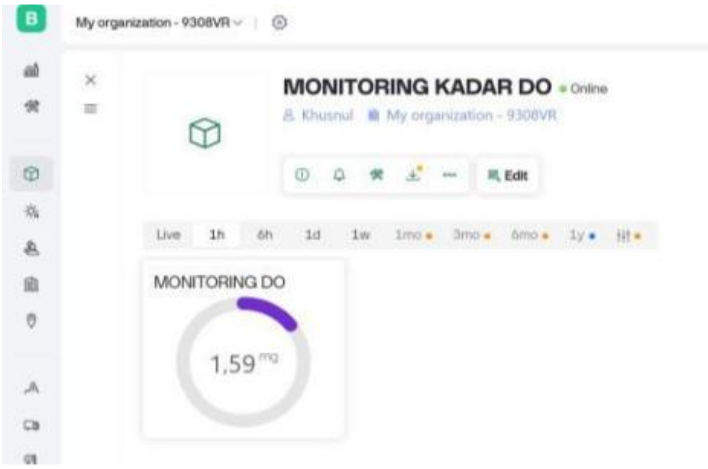

Figure 4. User Interface

Figure 4 shows the user interface of the Blynk application used to monitor dissolved oxygen levels in real time. This display consists of a value display gauge widget that displays the DO level in mg/L numerically and visually. The interface design is simple yet informative, allowing users to immediately understand the condition of the pond water by simply looking at the numbers and indicators on the screen. The data displayed is the result of sensor readings sent via the ESP32 microcontroller to the Blynk platform via a Wi-Fi connection. This display can be accessed via mobile devices or a computer browser, making this system flexible and easy to use for koi pond owners.

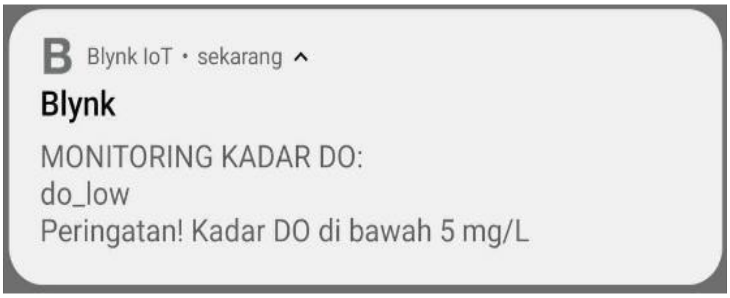

Figure 5. Warning Notification

Figure 5 shows a warning notification from the Blynk IoT application related to the dissolved oxygen monitoring system. This notification automatically appears on the user's device when the dissolved oxygen level in the water is detected below the safe threshold of 5 mg/L. This notification feature is very important because it serves as an early warning for users to take immediate action, such as turning on the aerator or changing the pool water, in order to maintain the survival of the fish. With this system, users do not need to constantly monitor the dashboard because they will immediately receive a notification when critical conditions occur.

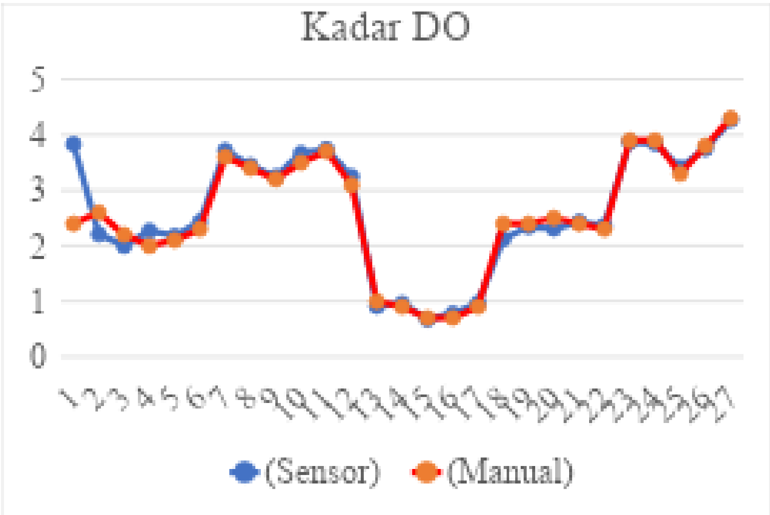

Figure 6. Comparison Chart

Figure 6 shows a graph comparing manual and sensor measurements of dissolved oxygen levels in the pond during 7 days of field testing. Based on this data, accuracy testing was conducted by comparing the system's readings with manual DO measurements, which showed an average system accuracy of 92.7% with an average deviation of 7.3%.

Table 1 system's precision test

Sampel										Mean	Stdv	Presisi
1	2	3	4	5	6	7	8	9	10			
3.48	3.44	3.39	3.42	3.40	3.44	3.36	3.37	3.29	3.26	3.38	0.07	98%

Table 1 shows the results of the system's precision test, in which one pool water sample was measured 10 times. The average reading value was 3.385 mg/L with a standard deviation of 0.07, resulting in a precision value of 98%. These results indicate that the system is capable of providing consistent measurement results under the same environmental conditions. The system was also able to withstand field testing with a portable power supply and did not experience any connection interruptions during the monitoring process.

Overall, this study shows that the developed IoT-based dissolved oxygen monitoring system can function well for carp farming applications. The system's ability to automatically read data, send results periodically, and provide real-time early warnings greatly assists farmers in making quick decisions to maintain water quality. With proven accuracy, precision, and stability in testing, this system is expected to be a practical and economical solution for sustainable pond water quality management in fish farming.

Discussion

This research successfully developed an Internet of Things (IoT)-based dissolved oxygen (DO) monitoring system using an ESP32 microcontroller, a dissolved oxygen sensor, and the Blynk application as a real-time monitoring platform. This system is designed to make it easier for carp farmers to monitor water quality, especially dissolved oxygen parameters, which are crucial factors in maintaining fish health and growth. Field test results show that the system is capable of accurately detecting DO levels in dynamic pond water conditions. During the 7-day testing period, recorded DO levels varied between 0.67 and 4.27 mg/L, all of which were below the ideal threshold for carp farming (>5 mg/L). These values were consistently sent and displayed in real-time via the Blynk application, enabling practical and efficient remote monitoring. Accuracy test results showed that the system had an average accuracy value of 92.7%, with an average error of 7.3%, compared to a calibrated manual DO meter. This indicates that the developed system is to be used as a monitoring tool in the field.

Despite showing good accuracy, several factors may have contributed to the small differences observed between the sensor readings and the manual DO meter. These include variations in measurement position and depth, slight time differences between manual sampling and real-time data transmission, and temperature effects on the analog DO sensor that were not fully compensated during field testing. Sensor calibration drift and potential fouling on the sensor surface after continuous submersion for several days may also have influenced the readings. In addition, noise from the power supply and the dynamic nature of dissolved oxygen concentration in pond water could have caused transient fluctuations that were captured differently by the two devices. These factors collectively explain the 7.3% deviation between both measurement methods. Nevertheless, the system's precision of 98% demonstrates consistent sensor performance, confirming its stability for long-term monitoring applications.

When compared with previous studies, the developed system demonstrates higher accuracy and better integration of features. For instance, Wicaksono et al. (2021) reported a DO monitoring accuracy of 88% using a galvanic sensor in freshwater ponds, while Yanti et al. (2023) achieved approximately 90% accuracy in a vannamei shrimp culture system. In contrast, the system proposed in this study reached 92.7% accuracy and 98% precision, supported by real-time data transmission and an automatic notification feature through the Blynk platform. Moreover, the inclusion of a local LCD display provides an additional advantage for direct on-site monitoring, which was not implemented in most previous designs. This comparison indicates that the developed system offers a more comprehensive, practical, and user-friendly solution for smalls aquaculture monitoring.

One of the advantages of this system compared to previous studies is the automatic notification feature that is sent when the dissolved oxygen level falls below the threshold. Based on a literature review, this feature has not been widely implemented. Studies by Wicaksono et al. (2021) and Bahri & Ridwan (2021) have used high-accuracy real-time systems, but these have not been equipped with automatic notifications. Meanwhile, Yanti et al. (2023) implemented a system with real-time monitoring and notifications, but did not include system feasibility analysis. Research by Sumangando et al. (2022) and Hamzah et al. (2023) focused more on measuring water quality in wastewater and marine waters, without real-time features or notification systems. Thus, the system developed in this study offers more comprehensive advantages, covering all aspects of notification, real-time monitoring, high accuracy, and an IoT-based monitoring platform using the Blynk application.

CONCLUSION

Based on the results of the design, implementation, and testing of the system, it can be concluded that the Internet of Things-based dissolved oxygen level monitoring system (was successfully developed using an ESP32 microcontroller integrated with a Dissolved Oxygen sensor, 1206 LCD, and the Blynk platform for real-time remote monitoring. This system is capable of continuously reading and displaying dissolved oxygen levels through a local display or smartphone application, as well as providing automatic notifications when the dissolved oxygen level falls below the threshold of 5 mg/L. The application of IoT technology has proven to be effective in improving the efficiency and responsiveness of water quality management in carp ponds. Accuracy test results show the system has an accuracy rate of 92.7% with an error of 7.3% compared to standard measuring instruments, making the data generated sufficiently representative of the actual pond conditions. This system provides a practical solution for remotely and continuously monitoring water quality, supporting faster and more accurate decision-making in freshwater aquaculture. Further research could be conducted to develop additional actuators, such as automatic aerator pumps that activate immediately when dissolved oxygen levels fall below the threshold, enabling automatic and faster intervention in critical water quality conditions without waiting for manual action from users.

ACKNOWLEDGEMENTS

The author would like to express his deepest gratitude to all parties who have provided assistance, support, and contributions in the process of completing the research entitled "Optimizing Water Quality in Goldfish Cultivation through an IoT-based Dissolved Oxygen Level Monitoring System". This research would not have been possible without the support and cooperation of various parties who have contributed, both directly and indirectly. Deep gratitude is addressed to the supervisor for the guidance, direction, and knowledge that has been provided during the research process and the preparation of this research. With his dedication, the author gained broader and deeper insights that became the basis of this research. The author also expresses appreciation to educational institutions, academic parties, and fellow students who have provided moral support, constructive discussions, and encouragement during the process of this research.

REFERENCES

Akbarurrasyid, M., Nurazizah, S., Furqon, D., Rohman, S., Kelautan, P., Pangandaran, P., Kunci, K., Mas Marwana, I., Carpio, C., & Pembenihan, M. (2020). Manajemen Pembenihan Ikan Mas Marwana (Cyprinus carpio) di Satuan Pelayanan Konservasi Perairan Daerah Wanayasa, Purwakarta, Jawa Barat Hatchery Management of Marwana Goldfish (Cyprinus carpio) in Wanayasa Regional Service Unit Conservation, Purwakarta, W. *Journal of Aquaculture and Fish Health*, *9*(1), 30–37. https://e-journal.unair.ac.id/JAFH

Bahri, S., & Ridwan, R. (2021). Pengaturan Oksigen Terlarut Berbasis Logika Fuzzy dan Monitoring Kualitas Air pada Budidaya Udang Vannamei Berbasis Web. *RESISTOR (Elektronika Kendali Telekomunikasi Tenaga Listrik Komputer)*, *4*(2), 111. https://doi.org/10.24853/resistor.4.2.111-120

Berlianti, R., & Fibriyanti. (2020). Perancangan Alat Pengontrolan Beban Listrik Satu Phasa Jarak JauhMenggunakan Aplikasi Blynk Berbasis Arduino Mega. *Jurnal, Sain, Energi, Teknologi & Industri*, *5 (1)*(1), 17–26. https://doi.org/10.31849/sainetin.v5i1.6398

Darmayani, S., Sa'diyah, A., Supiati, S., Muttaqin, M., Rachmawati, F., Widia, C., Pattiapon, M. L., Rahayu, E. P., Indiyati, D., & Sunarsieh, S. (2023). *Kesehatan Keselamatan Kerja (K3). Widina Bhakti Persada Bandung, Jawa Barat*.

Hamzah, F., Teguh Agustiadi, Mukti Trenggono, Eko Susilo, & Iis Triyulianti. (2023). Alternatif Pengukuran Konsentrasi Oksigen Terlarut Di Laut Indonesia Bagian Barat Pada Muson Tenggara. *Jurnal Ilmu Dan Teknologi Kelautan Tropis*, *14*(3), 405–425. https://doi.org/10.29244/jitkt.v14i3.41076

Ningsih, S. D., & Pratama, A. A. (2022). Penerapan Metode Just In Time sebagai Alternatif Pengendalian Persediaan Bahan Baku Pada PT BEHAESTEX, Pandaan Pasuruan. *JAMIN : Jurnal Aplikasi Manajemen Dan Inovasi Bisnis*, *4*(1), 58. https://doi.org/10.47201/jamin.v4i1.105

Pane, E. P., Arfiati, D., & Apriliyanti, F. J. (2023). Review: Respon Fisiologis Ikan terhadap Lingkungan Hidupnya. *Jurnal Aquatik*, *6*(2), 71–83. https://doi.org/10.35508/aquatik.v6i2.12921

Pieters, L. S. (2025). Pemantauan pH Produk Skincare berbasis IoT: Solusi untuk Keamanan Konsumen. *Edumatic: Jurnal Pendidikan Informatika*, *9*(1), 236–245. https://doi.org/10.29408/edumatic.v9i1.29644

Septiawan, M., Mantini, S., Sedyawati, R., & Mahatmanti, W. (2014). *Info Artikel*. *3*(2252), 3–8.

SNI. (1999). Produksi Induk Ikan Mas (Cyprinus carpio Linneaus) strain Majalaya Kelas Induk Pokok (Parent Stock). *Badan Standar Nasional*, 01-6131–1999.http://kkp.go.id/an-component/media/upload-gambar-pendukung/DIT PERBENIHAN/SNI Perbenihan/SNI Mas Majalaya/31 01-6131-1999.pdf

Sumangando, A., Kawung, N. J., Rompas, R. M., Untu, S. D., & Potalangi, N. O. (2022). Analisis Kebutuhan Oksigen Biologi, Oksigen Terlarut, Total Suspensi Solit Dan Derajat Keasaman pada Air Limbah Rumah Sakit Pancaran Kasih Manado. *Majalah INFO Sains*, *3*(1), 45–50. https://doi.org/10.55724/jis.v3i1.49

Susanto, F., Prasiani, N. K., & Darmawan, P. (2022). Implementasi Internet of Things Dalam Kehidupan Sehari-Hari. *Jurnal Imagine*, *2*(1), 35–40. https://doi.org/10.35886/imagine.v2i1.329

Syarifudin. (2016). Pengaruh pH terhadap Pertumbuhan dan kelangsungn Hidup Benih Ikan Biawan. *Skripsi*, 1–52.

Wagyana, A. (2019). Prototipe Modul Praktik untuk Pengembangan Aplikasi Internet of Things (IoT). *Setrum : Sistem Kendali-Tenaga-Elektronika-Telekomunikasi-Komputer*, *8*(2), 238. https://doi.org/10.36055/setrum.v8i2.6561

Wicaksono, D., Bhakti, T. L., Taruno, R. B., Subroto, M. R. S., & Mustikasari, A. (2021). A galvanic-based dissolved oxygen level monitoring sensor system in freshwater ponds. *Jurnal Teknologi Dan Sistem Komputer*, *9*(2), 83–89. https://doi.org/10.14710/jtsiskom.2021.13996

Yanti, H. A., Putri, D. A., & Fajriyah, S. Z. (2023). SIMULASI SISTEM MONITORING OKSIGEN TERLARUT (DO) PADA BUDIDAYA UDANG VANAME BERBASIS INTERNET OF THINGS (IoT). *Journal of Informatics and Communication Technology (JICT)*, *5*(1), 57–67. https://doi.org/10.52661/j_ict.v5i1.156