Monitoring oxygen levels of windu shrimp pond water using dissolved oxygen sensor based on wemos D1 R1

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ABSTRACT

This research applies an oxygen level monitoring system in tiger prawn ponds using a Dissolved Oxygen (DO) sensor based on Wemos D1 R1 with an Internet of Things (IoT) approach. Tiger prawn ponds, as cultivation centers, require regular monitoring of water quality. This system uses a DO sensor in water, processed by Wemos D1 R1, and the data is sent to Firebase Cloud for storage. The web application serves as a user interface for monitoring and analyzing data. The results of research at the Pandawa 1000 tiger prawn pond, Lanrisang Village, Pinrang, show the positive impact of IoT technology on pond management. The selection of the Wemos D1 R1 and use of the Dissolved Oxygen Sensor enables accurate and efficient measurement of oxygen levels, addressing shortcomings of previous research, especially the integration of the sensor directly into Firebase for real-time data storage and delivery. This development improves connectivity and real-time monitoring capabilities, crucial aspects in ensuring optimal pond water quality.

1. Introduction

Ponds are artificial ponds filled with water and used for aquaculture. [1] For successful cultivation, a cultivated organism, a living medium for the organism, and a cultivation site are required [2]. Aquaculture is an activity that increases fisheries production, it can be done traditionally, semi-intensive or intensively [1], [3].

Shrimp is one of Indonesia's leading exports which needs to be improved in quality and quantity on a large scale [4]–[6], Tiger prawns (Penaeus monodon), a type of shrimp native to Indonesia, are a leading fishery commodity because of their high selling price [7]–[9]. However, in 2015, there was a decline in tiger prawn production [10] due to environmental problems that threaten the sustainability of cultivator businesses. Water quality, including temperature, dissolved oxygen (DO), and oxygen levels, is a key factor in the success of cultivation [11], [12]. Unfortunately, many farmers still use manual methods to measure water quality, which can affect the effectiveness of fish farming [13].Therefore, it is necessary to increase cultivation activities to meet needs [14], [15].

Electronic technology has brought significant changes in periodic activity monitoring [16], [17], including automatic control in areas such as common dam water level monitoring applications [18]. IT advances, especially in IoT (Internet of Things) or embedded systems, are increasingly rapid [19]. IoT as a form of cooperation between systems, helps human work in this modern era [20]. An example of IoT development is the Wemos D1 R1, an ESP2866 based wifi board that allows microcontrollers to connect to the internet via wifi [21].

Internet of Things(IoT) is the concept of utilizing internet connectivity to keep devices always connected [22], [23]. The goal is to connect electronic devices via the internet, with the hope that the system created can help people in certain tasks or jobs [24]. IoT implementation can be used to create a Web-based system for controlling oxygen levels in tiger prawn pond water. IoT implementation can be used to create a Web-based system for controlling oxygen levels in tiger prawn pond water [25], [26].

Research on controlling pond water oxygen levels based on the Internet of Things (IoT) has been carried out by several researchers. Dania Eridani, Eko Didik Widianto, and Nur Kholid conducted research in 2020, creating a system that monitors and controls the water quality of tiger prawn ponds continuously and in real-time using IoT with the Message Queuing Telemetry Transport protocol [27]. In the same year, Gurun Ahmad Pauzi, Okta Ferli Suryadi, Gregorius Nugroho Susanto, and Junaidi developed a shrimp pond water quality monitoring system with Arduino which was integrated with a CPM1A PLC, using the dfrobot DO meter kit sensor, salinity sensor, DS18B20 waterproof sensor, and Dissolved Oxygen analogs [28].

Previous research still used Arduino UNO as a microcontroller, but it had shortcomings that needed further development. In the next research, we will use an IoT technology device, Wemos D1 R1, which can connect to the internet without the need to add a WiFi card. Additionally, the previous system processes and transmits data using an Arduino UNO, which is then displayed and analyzed in Microsoft Excel. Future research will use a Dissolved Oxygen Sensor directly connected to Firebase to store and send data, which can be displayed and analyzed in real-time via a website-based application. This research aims to develop a control system for tiger prawn ponds using website-based IoT technology, monitor oxygen levels in tiger prawn pond water, and is expected to support an increase in the number of tiger prawn exports in various countries.

2. Literature review The Proposed Method/Algorithm

2.1. DO (Dissolved Oxygen) Sensors

The dissolved oxygen sensor is part of an electrochemical sensor, the reaction of oxygen gas with an electrolyte solution produces an electrical signal with a magnitude proportional to the amount of oxygen concentration (Dfrobot) [29]. It has become the most noticed method in international research [30].

The following is a picture of the analog graphity sensor Dissolved Oxygen meter kit which is used to measure the value of oxygen levels in ponds, which can be seen in Fig. 1.

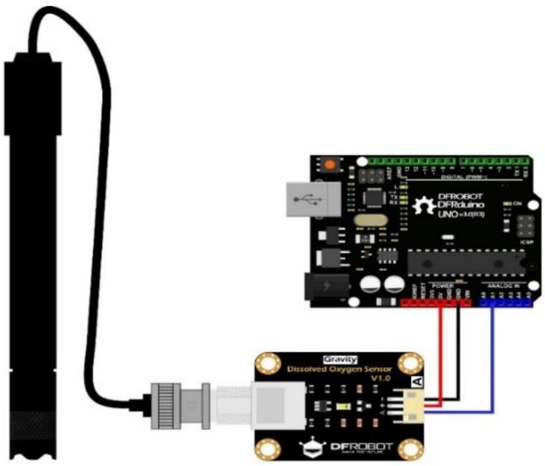


Fig. 1. Analog gravity sensor Dissolved Oxygen meter kit

The Dissolved Oxygen (DO) sensor used is a Dfrobot Analog Grafity product. Dissolved Oxygen Probe:

- Galvanic probe, no need for polarization time.
- Filling solution and membrane cap can be replaced, low maintenance cost Signal converter board.

- 3.3V~5.5V wide range power supply, compatible with most Arduino microcontrollers
- 0~3.0V Analog output, compatible with all microcontrollers with ADC function
- Gravity interface, plug and play, easy to use

The following are the specifications for dissolved oxygen investigations, which can be seen in Table 1.

Table.1 Dissolved Oxygen Investigation Specifications

No.	Specification	Information
1.	Type	Galvanic Probe
2.	Detection Range	0-20 mg/l
3.	Response Time	Up to 98% full response, within 90 seconds (25°C)
4.	Pressure Range	0- 50PSI
5.	Electrode service life	1 Year (normal use)
6.	Maintenance period	Membrane cap replacement period: 1- 2 months (in muddy water); 4- 5 months (in clean water) filling solution replacement period: once every month
7.	Cable length	2 meters
8.	Probe connector	BNC
9.	Operating voltage	3.3- 5.5V
10.	Output signal	0- 3.0V
11.	Cable connector	BNC
12.	Signal connector	Gravity Analog Interface (DO 2.0-3P)
13.	Dimensions	42mm*32mm

2.2. Wemos D1 R2

Wemos is a board that works with Arduino, especially for projects with an IoT concept [31], [32]. Different from other WiFi modules which require a microcontroller as a controller [33], which can be programmed via serial port or OTA (Over The Air) for wireless program transfer [34]. The type of Wemos used is Wemos D1 R1 as in Fig. 2.

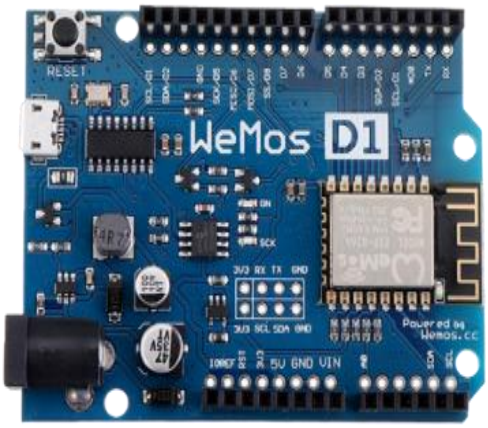


Fig. 2. Wemos D1 R1

Wemos D1 R1 is an update of Wemos D1 Mini which looks like the Arduino Uno R3 version of the CH340G driver [35].

3. Method

3.1. Stages Study

This research stage contains the following research stages as show in Fig. 3.

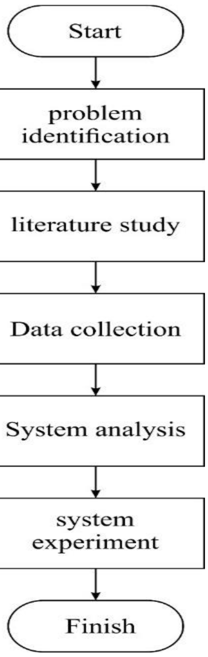


Fig. 3. Research Stages

- Identification of problems

  Identifying problems that occur in tiger prawn ponds in Lanrisang village, Pinrang. In monitoring oxygen levels manually.

- Study of literature

  Collecting references related to the implementation of water monitoring in tiger prawn ponds in Langrisang village, Pinrang. Using a Dissolved Oxygen sensor using Internet of Things technology.

- Data collection

  Conducting observations and interviews with tiger prawn pond farmers in Lanrisang village, Pinrang. To obtain data related to manually measuring oxygen levels in ponds.

- System analysis

  At this stage, start processing and analyzing the data or information obtained at the data collection stage by creating use case diagrams, class diagrams, activity diagrams, block diagrams, tool interconnections and tool schematic diagrams.

- System planning

  Start designing a system that will be built based on the data that has been collected by applying the Dissolved Oxygen sensor tool using Internet of Things technology.

3.2. Block System Diagram

The system block diagram, as seen in Fig. 4, includes the design of parts of the tool circuit used in this research, including the sensor input system, Wemos D1 R1 process, Modem Gateway, and Web output. The circuit is assembled after completion of each system block.

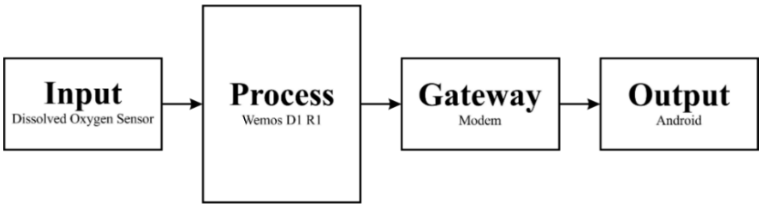


Fig. 4. Block Diagram System

3.3. Tool Architecture

The initial stage involves tiger prawn ponds as the main place for cultivation, functioning as the main living environment for tiger prawns. Water quality is crucial, measured through the main parameter, namely dissolved oxygen (DO) levels, which affect shrimp health and growth. The DO sensor in the water measures oxygen levels and sends data via the Wemos D1 R1, a wifi-based microcontroller. The data is sent to Firebase Cloud for storage and access via the Web, providing an integrated solution for effective monitoring and management of tiger prawn pond water quality. Schematic Diagram of IoT tools as show in Fig. 5.

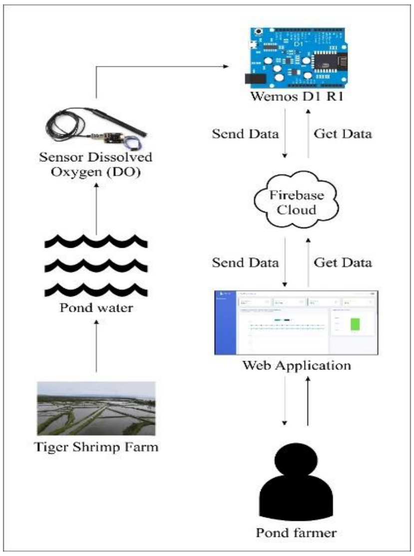


Fig. 5. Schematic Diagram of IoT tools

3.4. Flowchart System

At this stage, we begin to process and analyze the data and information obtained through intensive observations at the research location as show in Fig. 6.

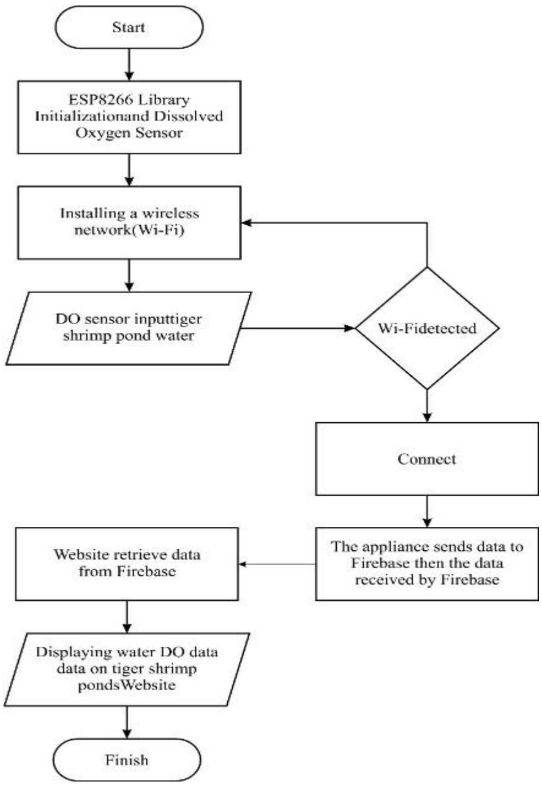


Fig. 6. System Flowchart

4. Results and Discussion

Traditional shrimp ponds in Waetuo, Pinrang Regency, South Sulawesi, have a land area of around 0.6 hectares, consisting of several pond plots spread across the area. This research creates an IoT tool for monitoring with the initial steps involving software configuration and hardware installation. Important in device configuration is the creation of sensor reading rules as the IoT device control center.

Hardware configuration involves establishing connectivity between components, as seen in the IoT hardware schematic diagram. The diagram shows the device architecture, with the Wemos D1 R1 sensor connected to the power supply and signal converter board, then connected to the DO device. After following the specified sequence, the next step is to enter code commands into the Wemos D1 R1 machine, including instructions for sending data to Firebase, which functions to send data to the Web application for monitoring.

Implementation of IoT devices in shrimp ponds. This tool is placed on the water surface using a styrofoam box that can float. The tip of the sensor is immersed in water, it is hoped that it will provide information according to the actual conditions of dissolved oxygen (DO) levels in shrimp ponds.

4.1. Data Collection Results

The research results after collecting data can be seen in the Table 2.

Table.2 Results of DO data collection in the morning

No	Date/Time	Morning	DO value	Weather Conditions	Note
1	02/24/2023	6:46	6.5	Hot	
2	02/25/2023	6:54	6.4	Hot	
3	02/26/2023	6:39	6.3	Rain	
4	02/27/2023	6:41	6.4	Hot	
5	02/28/2023	6:41	6.4	Hot	
6	01/03/2023	6:23	6.3	Rain	
7	02/03/2023	6:57	6.2	Sunny Cloudy	
8	03/03/2023	6:22	6.2	Sunny Cloudy	

From the results of collecting Dissolved Oxygen (DO) data in the morning, it is known that the DO value is in the range of 6.2 to 6.5, indicating that the water conditions in tiger prawn ponds are relatively adequate for shrimp life. Even though there are slight fluctuations, the DO value remains safe. Weather conditions such as "Hot," "Rainy," and "Sunny, Cloudy" are recorded to provide environmental context during the measurement. On 02/26/2023, during rainy weather, the DO value fell slightly to 6.3, indicating the influence of weather on dissolved oxygen levels. These data provide an initial picture of how environmental factors, particularly weather, affect water quality in the morning. By understanding this variability, farmers can take steps to maintain optimal conditions in tiger prawn ponds and increase aquaculture yields. The results of taking DO data during the day as show in Table 3.

Table.3 Results of DO data collection during the day

No.	Date/Time	Afternoon	DO value	Weather Conditions	Note
1	02/24/2023	14:17	6.6	Hot	
2	02/25/2023	14:33	6.5	Hot	
3	02/26/2023	14:26	6.4	Rain	
4	02/27/2023	14:08	6.5	Hot	
5	02/28/2023	14:19	6.5	Hot	
6	01/03/2023	14:43	6.4	Rain	
7	02/03/2023	14:51	6.3	Sunny Cloudy	
8	03/03/2023	14:14	6.3	Sunny Cloudy	

From the results of taking DO data during the day, it is known that DO values range from 6.3 to 6.6, indicating relative stability during the measurement period. Even though there are variations in DO values, minimal changes are still within the range that supports shrimp life. On 02/26/2023, when it rained, the DO value reached 6.4, reflecting the impact of weather on dissolved oxygen levels. Weather conditions such as "Hot," "Rainy," and "Sunny, Cloudy" are recorded to provide environmental context. This data provides a more detailed view of daytime DO values and the impact of weather conditions. With this understanding, further monitoring and management can be carried out to maintain optimal water quality in tiger prawn ponds and support healthy growth.

4.2. Tool Comparison Data

Comparative testing between the DO Meter and the DO sensor aims to assess the accuracy of both. Both tools were dipped in shrimp ponds with similar treatment, and the results of observations of DO levels were displayed on the Web. The purpose of the sensor is to calculate the error rate recorded in Table 4. Observations are divided into two types: systematic error, which has a fixed effect on the measurement results, and random error, which is random.

Measurement formula:

$$error : | X - Xi \quad (1)$$

$$\%error : | \frac{(X-Xi)}{X} x\ 100\% | \quad (2)$$

Formula description:

X =DO Real

Xi =DO Measurable

%error = Systematic error

Then it can be applied to look for errors and calculate the %error, namely:

$$error : Real\ Temperature - Measured\ Temperature$$

$$\%error : \frac{Real\ Temperature - Measured\ Temperature}{Real\ Temperature}\ x\ 100\% \quad (3)$$

Table.4 Comparison of DO Meter Tools with DO Sensor Tools

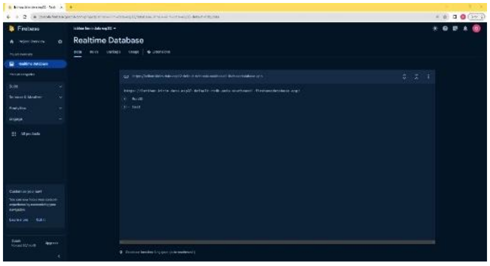
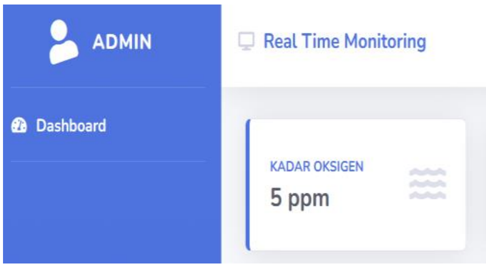
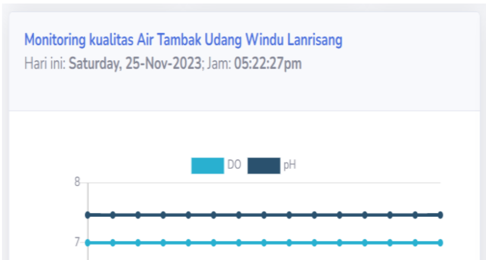
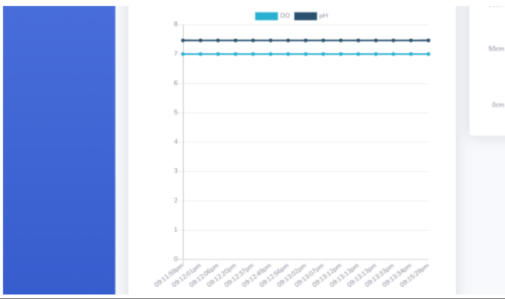
No	DO value	Manual tool DO value	*Error*	% Error
1	6.6	6	0.6	9.09%
2	6.5	6	0.50	7.69%
3	6.4	5	1.4	21.88%
4	6.5	6	0.5	7.69%
5	6.5	6	0.5	7.69%
6	6.4	5	1.4	21.88%
7	6.3	5	1.3	20.63%
8	6.3	5	1.3	20.63%
Average error and % error			0.94	14.65%

From the comparison between the DO Meter and the DO sensor in the table, it can be seen that the DO sensor has a slightly lower DO value than the reference value measured by the DO Meter. The average error is 0.94, with an average error percentage of 14.65%. Even though there are deviations, the error percentage is relatively small, around 14.65%, indicating that the DO sensor has acceptable accuracy in measuring dissolved oxygen levels.

4.3. Testing

Testing uses the Black Box method to ensure the entire system is tested according to functionality, interface, data model and data access. The test series is carried out through direct access to the Web application with several test stages according to the following table plan. Test results as show in Table 5.

Table.5 Test result

No	Test Cases	Target	Visualization	Test Results
1.	Receives data from Firebase and displays it.	It is hoped that it will be able to display DO data from Firebase.		Succeed
2.	Card View indicator to display pond Do monitoring data.	It is hoped that it will be able to display DO data on the Web.		Succeed
3.	Time and place using coordinates using the Web.	It is hoped that it can accurately contain the time and place of the pond area.		Succeed
4.	Pond water DO graph data has appeared.	It is hoped that it can load data in graphic form on the Web.		Succeed

5. Conclusion

Based on research on Pandawa 1000 tiger prawn ponds in Lanrisang Village, Pinrang Regency, the implementation of Internet of Things (IoT) technology using Wemos D1 R1 and Dissolved Oxygen Sensors has had a positive impact on shrimp pond management. This choice of devices and sensors enables accurate and efficient measurement of oxygen levels, overcoming several shortcomings of previous studies. This development provides superior connectivity and real-time monitoring capabilities, vital for ensuring optimal pond water quality. This system is expected to make a significant contribution to farmers by providing accurate and fast information about water oxygen levels, opening up opportunities to increase efficiency and sustainability in tiger prawn cultivation. Based on the conclusions above, the author would like to add suggestions that can be used as input: 1) Integrate various sensors, such as temperature or salinity, to provide a more comprehensive understanding of the environmental conditions of the pond; 2) Examining the impact of weather conditions, such as rain or temperature changes, on oxygen levels in pond water; 3) Examining the possibility of developing an automatic control system based on sensor data to optimize environmental conditions in ponds automatically; 4) Conduct research at different farm locations or with varying environmental conditions to validate research results and understand the extent to which results can be generalized.

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