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Remote Water Quality Monitoring System In Shrimp Ponds With *Photovoltaic* (PV)-Based Energy Source

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ABSTRACT

Introduction: Shrimp has great potential to be used as a business field in Indonesia. Especially in Parigi Regency itself, there are now many shrimp ponds that can be found because of the benefits obtained, so people are interested in making shrimp farming a livelihood. One of the main problems of shrimp ponds is pond water quality. There are several factors that affect pond water quality, namely water temperature, water pH, and water salinity, good pond water quality management can maintain quality standards and can increase shrimp yield and productivity **Method:** To facilitate the shrimp farmers, innovations need to be made in order to help the shrimp farmers manage their shrimp ponds, therefore using a remote water quality monitoring was system in shrimp ponds with photovoltaic (PV) based energy sources is expected to be an innovation in managing shrimp ponds, especially in monitoring water quality in shrimp ponds. The monitoring system designed using the NRF24L01 module as a remote communication module, at the research location the distance from the shrimp pond to the house is approximately 100 meters, so the tools that have been designed can facilitate shrimp farmers to monitor the shrimp pond **Results and Disscussion:** The results of testing the DS18B20 temperature sensor compared with a digital thermometer measuring instrument get an average error of 0.014%. The test results of the pH sensor compared to the pH meter get an average error of 0.026%. TDS sensor test results compared with the TDS meter get an average error of 0.04%. **Conclusion:** The temperature, pH, and salinity monitoring system uses transmitter and receiver modules, where the transmitter module reads and sends data to the receiver module wirelessly with NRF24L01. Using DS18B20 temperature, pH, and TDS sensors, as well as energy from photovoltaics, this system helps shrimp farmers monitor pond water quality remotely.

1. Introduction

Shrimp is one of the fastest-growing aquaculture commodities in Indonesia due to increasing consumer demand, especially to meet the needs of the international market. According to the Ministry of Maritime Affairs and Fisheries (KKP) in 2022, in 2019 the value of shrimp exports amounted to US$ 1.71 billion, in 2020 it increased by US$ 2.04 billion and in 2021 it continued to increase by US$ 2.2 billion. This shows that shrimp farming has a significant contribution to national

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economic development [1]. Good pond water quality management can maintain quality standards and can increase shrimp yield and productivity [2]. This tool can help shrimp farmers in monitoring pond water quality from a distance if the farmers are not in the shrimp pond area and can also monitor the quality of shrimp pond water through the LCD installed on the tool if the farmers are in the shrimp pond area [3,4,5]. This is done to prevent problems in shrimp and keep shrimp healthy and free from disease because water quality is very influential for the survival of shrimp [6,7]. The monitoring data will be stored so that it can be used as a prediction to monitor the water quality of shrimp ponds. This system is entitled "Remote Water Quality *Monitoring* System in Shrimp Ponds with Photovoltaic (PV) based Energy Source" using sensors to monitor the water quality of shrimp ponds.

2. Research Method

2.1 Research Tools and Materials

In the preparation and making of this thesis, using several kinds of tools and materials described in the sub-chapters below:

- Tools consist of Tin Suction, Drill, Solder, Fire Light Switch, Digital Voltmeter, Screwdriver, Battery, Arduino IDE
- The materials consist of *a Photovoltaic* (PV), *Solar Charge Controller*, Battery, Arduino Uno, pH Sensor, TDS Sensor, Temperature Sensor, nRF24L01, *Box Project*, LCD, LED, *Stepdown*, Cable, *Button*, *DC Jack*, Adapter, Tin, PCB.

2.2 Research Location

This research was conducted in Dolago village, South Parigi sub-district, Parigi Moutong district, Central Sulawesi province.

2.3 Research Stages

- Flowchart

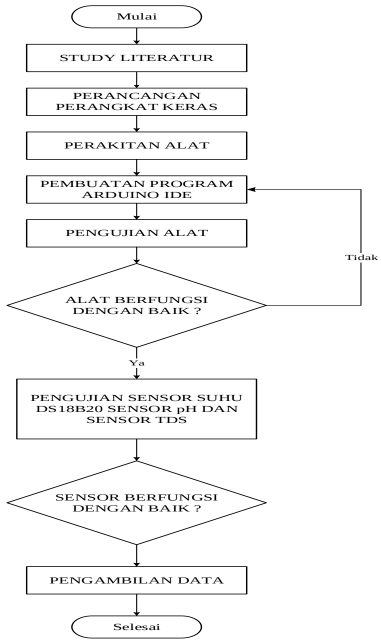

Fig 1. Research Flowchart

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- Block Diagram

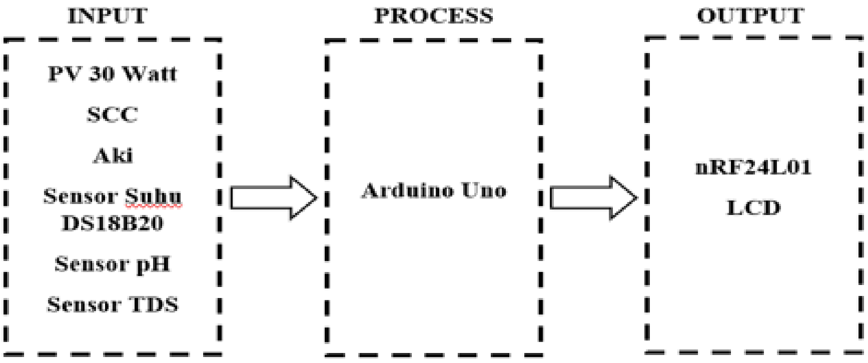

Fig 2. Block Diagram

- System Design
  - Receiver System Design Schematic

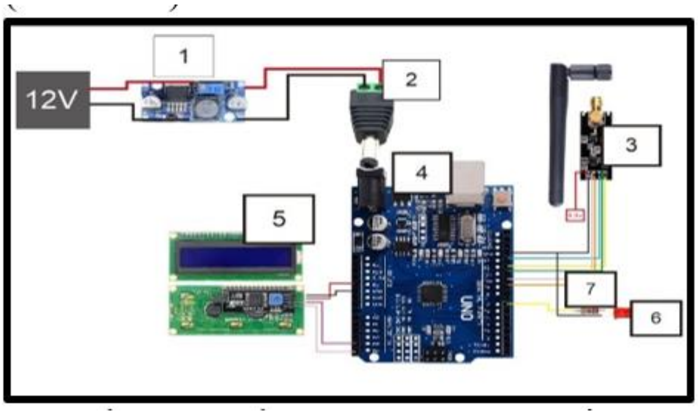

Fig 3. *Receiver* System Design Schematic

- *Transmitter* System Design Schematic

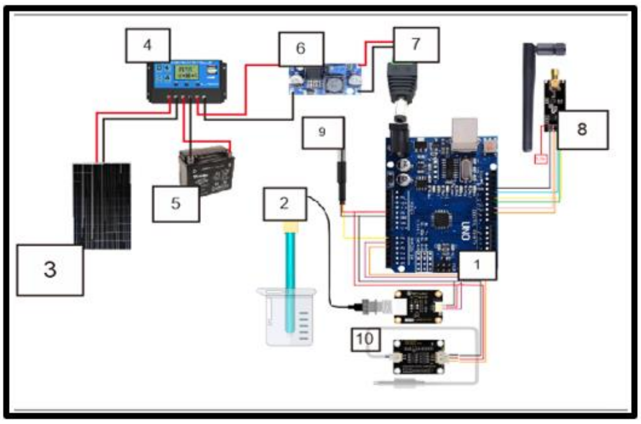

Fig 4. *Transmitter* System Design Schematic (*Transmitter*)

- Transmitter System Design

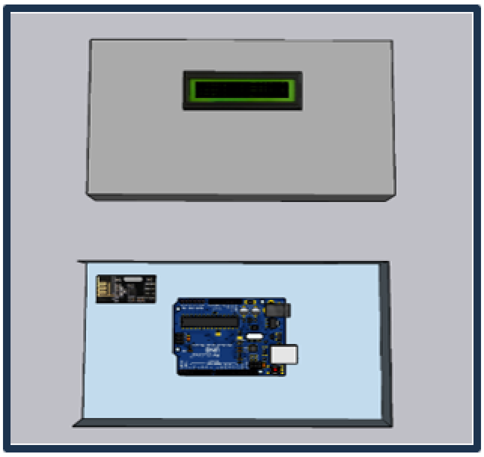

Fig 5. Transmitter System Design

- *Flowchart of* Tool Working Principle

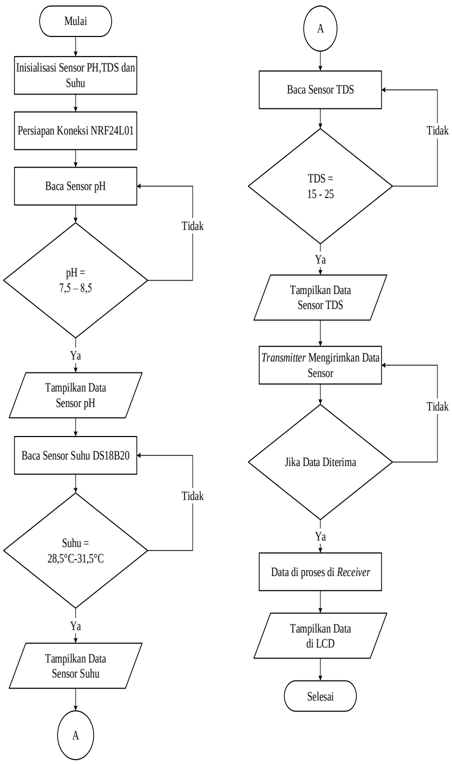

Fig 6. *Flowchart of* Tool Working Principle

3. Results and Discussion

From the results of the design and research entitled Remote Water Quality *Monitoring* System in Shrimp Ponds with *Photovoltaic* (PV) based Energy Sources, the results can be presented in the form of tools, *software*, data, and data analysis.

3.1 Physical Form of the Tool

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Design of a remote water quality monitoring system in shrimp ponds with Photovoltaic-based energy sources [8]. This tool consists of several components, namely, Photovoltaic 20Wp, *Solar Charger Control* (SCC), *Battery* (*battery*), *Step Down*, Arduino Uno, nRF24L01 module, temperature sensor, pH sensor, TDS sensor, LCD, and LED. The following is the physical form of the tool can be seen in Figure 7.

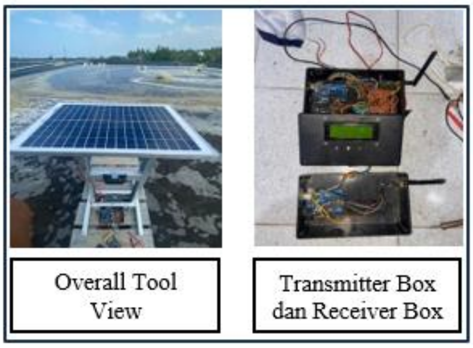

Fig 7. Physical Shape of the Tool

3.2 Sensor Testing

Sensor testing includes testing temperature, pH, and TDS sensors where the sensors used will be compared with the types of measuring instruments sold in the market, so that by comparing the sensors used with conventional measuring instruments, an error value will be obtained that can be used as a reference to see the level of accuracy of the sensors used in this study.

a. DS18B20 Temperature Sensor

Table 1. Temperature Sensor Testing Results

Hours	DS18B20 Temperature Sensor (°C)			Digital Thermometer (°C)			Error (%)
	Day-			Day-			
	1	2	3	1	2	3	
08.00	31,4	32,9	32,4	31	32	32	0,018
09.00	33,9	36,4	33,9	33	35	34	0,022
10.00	35,9	38,4	36,4	36	38	36	0,006
11.00	38,4	40,4	39,9	38	40	40	0,006
12.00	41,9	42,4	41,4	42	41	41	0,014
13.00	40,4	42,9	41,4	40	41	40	0,031
14.00	38,4	38,9	39,4	38	37	39	0,024
15.00	35,9	32,4	35,9	36	32	36	0,002
16.00	32,4	33,4	33,9	32	34	34	0,003
Average							0,014

From the test results of the remote water quality *monitoring* system in shrimp ponds for temperature parameters, using a DS18B20 temperature sensor by immersing the sensor and digital thermometer in shrimp pond water. The goal is to test the durability of the sensor when immersed in water continuously. The average percentage *error* obtained using the equation formula 2.9 is 0.014%, this indicates that the sensor used gets a lower accuracy *error* compared to previous research.

b. Testing the pH Sensor

Table 2. pH Sensor Testing Results

Hours	**pH Sensor**			**pH Meter**			**Error (%)**
	Day-			**Day-**			
	1	**2**	**3**	**1**	**2**	**3**	
08.00	6,5	6,5	6,7	6,7	6,6	6,9	0,025
09.00	6,5	6,8	6,9	6,8	7,1	7,1	0,038
10.00	7,2	7,1	7,2	7,5	7,3	7,4	0,032
11.00	7,2	7,4	7,5	7,4	7,5	7,5	0,013
12.00	7,5	8,1	7,2	7,6	8,2	7,4	0,017
13.00	8,1	8,5	7,9	8,3	8,6	8,1	0,02
14.00	8,2	8,2	8,5	8,5	8,5	8,7	0,031
15.00	7,7	7,9	8,5	7,9	8,1	8,6	0,0203
16.00	7,1	7,5	7,6	7,4	7,7	7,9	0,035
Average							0,026

From the test results of the remote water quality *monitoring* system in shrimp ponds for the pH parameter, using a pH sensor by immersing the sensor and pH meter in shrimp pond water. This pH sensor is not supported to be immersed continuously in water. The average percentage *error* obtained using the equation formula 2.9 is 0.026%, based on these data it can be seen that the measurement value between the pH sensor and the conventional pH meter used does not have a significant difference, so using these two measuring instruments can produce an accurate value for measuring pH in shrimp ponds.

b. TDS Sensor Testing

Table 3. TDS Sensor Testing Results

Hours	**TDS Sensor (Ppt)**			**TDS Meter (Ppt)**			**Error (%)**
	Day-			**Day-**			
	1	**2**	**3**	**1**	**2**	**3**	
08.00	49	52	54	52	54	56	0,043
09.00	49	52	54	52	55	56	0,05
10.00	49	52	54	51	53	57	0,037
11.00	50	53	55	53	53	58	0,037
12.00	50	53	55	52	55	58	0,042
13.00	50	51	54	51	52	56	0,025

14.00	49	51	54	51	53	57	0,043
15.00	50	50	52	52	52	55	0,044
16.00	50	50	52	53	52	53	0,038
Average							0,04

From the test results of remote water quality *monitoring* systems in shrimp ponds for salinity parameters, using TDS sensors and TDS meters by immersing sensors in shrimp pond water. The average percentage *error* obtained using the equation of formula 2.9 is 0.04%, based on these data it can be seen that the measurement value between the TDS sensor and the conventional TDS meter used does not have a significant difference, so using these two measuring instruments can produce an accurate value for measuring salinity values in shrimp ponds.

d. LCD Display

The display on the LCD that shows the data results from testing the DS18B20 temperature sensor, pH sensor, and TDS sensor can be seen in Figure 4.2 below:

Fig 8. LCD Display

3.3 Line Impedance Calculation

In this study using a 20 WP solar panel where the output value of the solar panel will be measured voltage and current using a digital multimeter and pyranometer to measure the intensity of sunlight. Data collection was carried out for 3 days from 08.00 to 16.00 with the preparation stage, installation of measuring instruments, comparison and data retrieval process, and manual data collection was carried out with a break of 1 hour, then the average value of the measurement results was obtained as in table 4.

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Table 4. PV Output Measurement Result Data

DATA OUTPUT PHOTOVOLTAIC (PV)				
Hari Pertama				
No	Waktu	Intensitas Cahaya (W/m²)	Tegangan (V)	Arus (A)
1	08.00	707,6923077	12,1	0,76
2	09.00	769,2307692	12,1	0,82
3	10.00	815,3846154	12,4	1,12
4	11.00	846,1538462	12,8	1,02
5	12.00	930,7692308	13	1,13
6	13.00	876,9230769	12,7	0,92
7	14.00	800	13,1	1,21
8	15.00	723,0769231	13,6	0,91
9	16.00	623,0769231	13,6	0,29
Hari Kedua				
No	Waktu	Intensitas Cahaya (W/m²)	Tegangan (V)	Arus (A)
1	08.00	715,3846154	12,2	0,86
2	09.00	784,6153846	12,2	0,89
3	10.00	807,6923077	12,2	1,12
4	11.00	876,9230769	12,8	1,45
5	12.00	923,0769231	13,2	1,35
6	13.00	892,3076923	13	0,54
7	14.00	823,0769231	13,2	1,03
8	15.00	792,3076923	13,5	0,74
9	16.00	692,3076923	13,5	0,32
Hari Ketiga				
No	Waktu	Intensitas Cahaya (W/m²)	Tegangan (V)	Arus (A)
1	08.00	726,9230769	12,9	1,32
2	09.00	774,6153846	12,9	1,45
3	10.00	838,4615385	13,2	1,35
4	11.00	869,2307692	13,3	1,4
5	12.00	915,3846154	13,3	0,97
6	13.00	930,7692308	13,5	1,28
7	14.00	792,3076923	13,5	1,03
S8	15.00	699,2307692	13,5	0,59
9	16.00	664,6153846	13,5	0,37

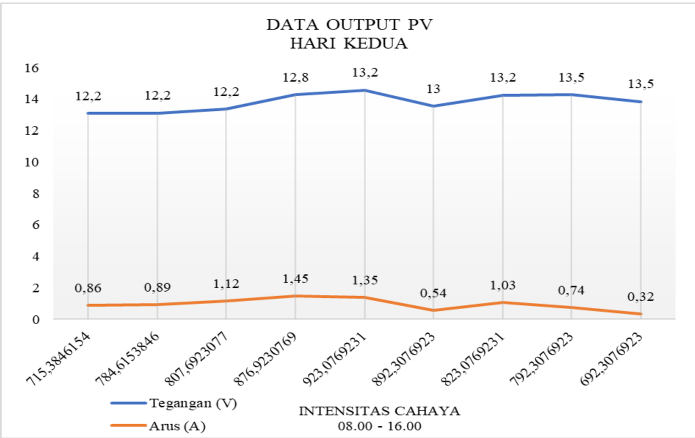

Fig 9. Graph of Second-Day PV Output Data

Based on the graph shown in the figure above, it can be seen that the output of photovoltaic (PV) that has been tested for 8 hours shows the voltage value produced by photovoltaic (PV) is increasing every hour so that the voltage value produced can be maximized. As for the value of the current produced by the photovoltaic (PV), it can be seen that during the 8 hours of testing carried out, the value of the current produced fluctuates according to the intensity of the light obtained by the photovoltaic (PV).

3.4 Calculating Load Power

To calculate the load power (P) and daily energy on the device, equation 2.4 and equation 2.6 can be used:
Load Power:

$P = V \times I$

Daily Energy:

$E_{DC} = P_{beban} \times t_{Operaty}$

For day 1 load power

$P_1 = V_1 \times I_1$

$= 13,6 \times 0,29$

$= 3,9$ W

$E_{DC_1} = P_{beban} \times t_{Operaty}$

$= 3,9 \times 8$

$= 31.2$ wh

3.5 Calculating Peak Power

To calculate the peak power (P) in PLTS, equation 2.1 PLTS = KWh / 4.8 h can be used, then the peak power calculation is as follows:

PLTS = KWh / 4.8 h
= 0,1055 / 4,8
= 0.022 KWp = 22 wp

3.6 Calculating the Number of Modules

To calculate how many solar modules are used with a peak power of 22 Wp is 1 unit of 20 Wp PV module.

3.7 Determining the number of battery packs

The required data related to battery specifications and battery energy requirements that have been calculated in previous calculations, need to first determine the voltage (Vdc), *Ampere Hour* (AH), and DOD of the battery, according to the manufacturer's specifications, in this study using 12 Vdc battery specifications, 7 AH and DOD 50%.

3.8 Calculation of How Long a Battery Can Last without Recharge

To calculate how long the battery can supply the load without recharging from *photovoltaic* can use formula 2.3:

I = P/V
Where:
P = Power (Watt)
V = Voltage (Volt)
I = Current (Ampere)

Then we get:
P = 19 Watts
V = 12 V

I = P/V
= 19 W/12 V = 1, 58 A
Long usage time = 7.5 AH / 1.58 A = 4.75 Hours usage time

3.9 Experimental Data of Monitoring Tool

In this study, experiments were conducted from a remote water quality monitoring tool on shrimp ponds with *photovoltaic* (PV) based energy sources where the test was by measuring the output value of voltage and current from 20 Wp solar panels and then programming the circuit of the tool by activating the tool for three days starting from 08.00 - 16.00.00, when the water quality monitoring tool in the shrimp pond works, the temperature, pH and TDS sensors will read the temperature, pH and salinity levels of water in the shrimp pond which will be read from the *transmitter module* will be sent to the *receiver module* using a *wireless* signal connected using the nRF24L01 module to display data that has been read by sensors in the *transmitter module* which will be displayed in the form of writing on the LCD on the *receiver* module, The data that will be displayed on the *receiver* module is in the form of measurement data in the form of numbers and displays the status of water conditions in shrimp ponds, so that later shrimp farmers can easily find out the condition of the water in their shrimp ponds. The test results in data that has been done for 3 days can be seen in Table 1, Table 2, and Table 3.

4. Conclusion

The temperature, pH, and salinity monitoring system is designed using two modules, namely the transmitter and receiver modules, where each module has a different function. The receiver module functions to receive and display data, while the transmitter module reads the temperature, pH, and salinity values sent to the receiver module using a wireless system from the NRF24L01 remote communication module. This water quality monitoring system uses a DS18B20 temperature sensor, pH sensor, and TDS sensor, as well as an energy source from photovoltaics, which helps shrimp farmers monitor water conditions in shrimp ponds periodically from a distance. Testing of water temperature, pH, and salinity sensors shows that the average error percentage for the temperature sensor is 0.014%, the pH sensor is 0.026%, and the TDS sensor is 0.04%, so that the accuracy of the monitoring system reaches 99.99% for temperature, 99.97% for pH, and 99.96% for salinity. The DS18B20 temperature sensor is suitable for use because it is waterproof, while the pH and TDS sensors cannot be continuously immersed because it can reduce the effectiveness of the sensor.

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