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A MONITORING SYSTEM OF WATER QUALITY BASED ON ARDUINO FOR TILAPIA POND

Fitri Amelia[1], Yohandri[1*], Asrizal[1], Mairizwan[1]

[1] *Departmen Fisika, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*

Corresponding author. Email: yohandri@fmipa.unp.ac.id

ABSTRACT

The problem that often occurs in fish farming is fish mortality caused by changes in pond water quality. One of the causes of changes in pond water quality is caused by changes in water pH levels, temperature, and turbidity of pond water. So far, measuring the quality of pond water has been done manually. It is necessary to design a monitoring system to provide warnings regarding the quality of fish pond water. The aim is to provide information if the water value is below the optimal value for fish development. This research is engineering research. The measurement techniques used are direct and indirect measurement. Direct measurement techniques are carried out by comparing data on pH, temperature, and turbidity levels between standard tools and measuring devices. The indirect measurement technique is done by analyzing the data. Based on the results of the Arduino-based tilapia pond water quality monitoring system, it consists of performance specifications for tools built with three sensors, namely pH, DS18B20, and turbidity sensors, and design specifications are divided into characterization, accuracy, precision, and tool testing. The average measurement accuracy of the pH sensor is 95%, the DS18B20 temperature sensor is 97% and the turbidity sensor is 94%. While the average accuracy of the pH sensor and DS18B20 temperature sensor is around 99% and the turbidity sensor is around 97%. With the data that has been obtained from the components of the measuring instrument, it can be stated that the measuring instrument can work properly.

Keywords : pH Sensor, DS18B20 Sensor, Turbidity Sensor, Tilapia.

I. INTRODUCTION

Aquaculture is one of the potential sectors that can be developed to improve people's welfare. Fish farming itself is an activity that is mostly carried out by the people of Indonesia. In Indonesia, various types of fish are popular for cultivation, such as shrimp, milkfish, catfish, catfish, tilapia, and so on. Tilapia is a fish often consumed by the community and contains nutrients almost the same as other freshwater fish. The advantage possessed by tilapia is that it is easy to develop and cultivate because of its high survival, relatively fast growth, and relatively large size and resistance to changes in environmental conditions. For its survival, tilapia can live in deep and wide waters or narrow and shallow ponds, such as tarpaulin and concrete ponds [1].

Water quality is one factor that greatly influences the success of fish farming. For fish growth, water quality is the suitability of water for the survival and growth of fish [2], namely by ensuring the health and performance of the fish being cultivated [3]. To keep fish in, of course, you have to pay attention to aspects of water feasibility [4]. To describe the quality of fish pond water can be observed based on several parameters, namely the degree of acidity (pH) [2], water temperature, and turbidity [5].

The pH conditions of the water needed for tilapia cultivation are around 6.5 -8.5 and the temperature is around 25℃ - 30℃ [6], and the maximum turbidity limit is 50 NTU [7]. The pH and temperature conditions of the water in the pond can change. Changes in pH and temperature are influenced by natural conditions and also by humans. For changes that are caused by natural conditions such as continuous rain, extreme heat, and extreme weather changes. Changes that are influenced by humans such as the process of giving a lot of feed affect the pH level of the water in the pond. Acidic conditions or alkaline will affect the life of the fish in it.

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In fish life, if the temperature is very low it will cause a decrease in the level of immunity in tilapia, whereas if the temperature is very high it causes the fish to be infected by bacteria and viruses [8]. Diseases caused by bacteria cause fish mortality above 80% in a relatively short time [6]. Acidic water will be harmful to fish because it tends to be a place for disease to develop, resulting in CO_2 fermentation. If the pH of the water is less than 7, it will reduce nitrification activity, whereas if the pH is less than 4 and more than 11, it can be toxic to fish.

The turbidity of the water that occurs can affect the ability of the water to transmit light into the water [9]. Turbidity is a water condition that is not clear caused by individual particles (suspended solids) which are generally invisible to the naked eye and are similar to smoke in the air. The water will be more turbid if there are too many particles in the pond water. Water turbidity that occurs in ponds, cages, and floating net cages can occur due to colloidal silt particles and dissolved organic matter [10].

The problem that often occurs is fish mortality caused by changes in pond water quality which causes fish to get sick [11]. The success of fish farming can be achieved with continuous monitoring. So it is necessary to have a pond water quality monitoring system that can measure parameters in real-time to maintain the quality of tilapia [2]. One of the causes of changes in pond water quality is caused by changes in water pH levels, temperature, and turbidity of pond water. So far, measurements of pond water quality have been carried out manually and are usually carried out too late, causing fish deaths [12].

The solution that can be offered to overcome the problem of fish mortality is to use a monitoring system. The monitoring system uses a monitoring and control system on the system. Monitoring is used to monitor the output generated by the sensors used in the system. At the same time, control is used to control the electronic components used in the system. Monitoring can be used to provide warnings about the quality of fish pond water. The aim is to provide information if the water value is below the optimal value for fish development. Previous research entitled Arduino-Based PH Meter [13]. This study uses Arduino as a microcontroller to control the input and output of the sensors used. However, this tool only uses a pH sensor and a pH meter to measure the pH of pond water. The resulting output will be displayed on the LCD used.

Based on this, in this study, a monitoring system will be designed that will be used to monitor the condition of pH, temperature, and turbidity of pond water. This tool uses Arduino as a microcontroller. To measure the quality of pond water, a pH sensor, a DS18B20 temperature sensor, and a turbidity sensor are used. The measurement results from the sensor output will be displayed on the LCD. If the pond is at a pH of less than 4 or more than 11, the pond temperature is less than 25 or more than 30 and the turbidity of the fish pond water is more than 100 NTU, the LED will light up as a reminder to immediately clean the pond water so it doesn't cause death to the fish.

II. METHOD

This type of research is engineering research. The stages in this study include ideas and task clarity, conceptual design, function geometry arrangement, detailed design, and model-making and testing of tools. The purpose of this research is so that it can be used to make improvements to the testing methods or procedures and improvements in the design itself. The main procedures of engineering research are shown in Figure 1.

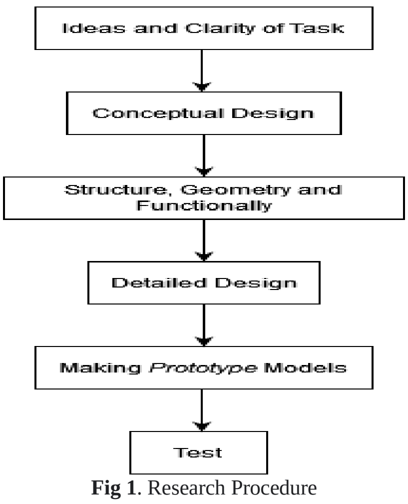

Fig 1. Research Procedure

To start this research, the first thing that must be done is to look for ideas that can be obtained by searching literature studies related to the research subject. A literature study is conducted to collect information that can be obtained from books, theses, articles, and journals related to the research subject. Through this literature study, it will be obtained the variables that will be examined, the things that have been done, and the things that will be done. With this discussion of ideas and clarity, new perspectives on research will be obtained. Next, a conceptual design is carried out which is used to modify the problems obtained from the ideas before forming a system for the research that will be created. Then there is the geometric arrangement and function used according to the function of each component used. Detailed design consisting of hardware design and software design of the system being created. After the design of the system is created, the next step is to create the system itself, the last of which is testing the system itself.

The components of the system to be created can be arranged geometrically according to the function of each component. The arrangement of the fish pond water quality monitoring system can be seen in Figure 2.

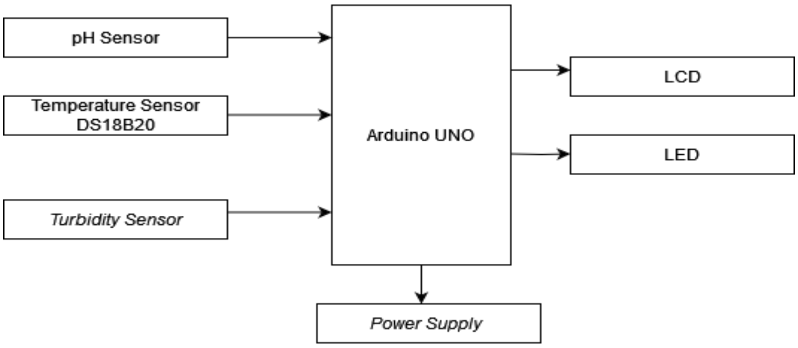

Fig 2. Geometry Arrangements and Functions

Figure 2 it is explained that the tool system to be designed consists of input circuits using a power supply. The pH sensor is used to measure the acidity or base level of pond water, the DS18B20 temperature sensor is used to detect pond water temperature, and the turbidity sensor is used to measure the turbidity level of pond water. Meanwhile, Arduino Uno is used to control input and output from sensors, and the results obtained will be displayed on the LCD screen. If the quality of the fish pond water exceeds a predetermined limit, the LED will turn on as a warning to immediately clean the pond.

Making the tool that will be used consists of hardware design and software design. For hardware design, Arduino Uno is used to process the input and output of the sensors used. The hardware design used can be seen in Figure 3.

Fig 3. Hardware Design

After the hardware design is complete, then the software design is carried out. For designing this software, Arduino software is used, which is then downloaded to Arduino Uno. The Arduino software design is shown in Figure 4.

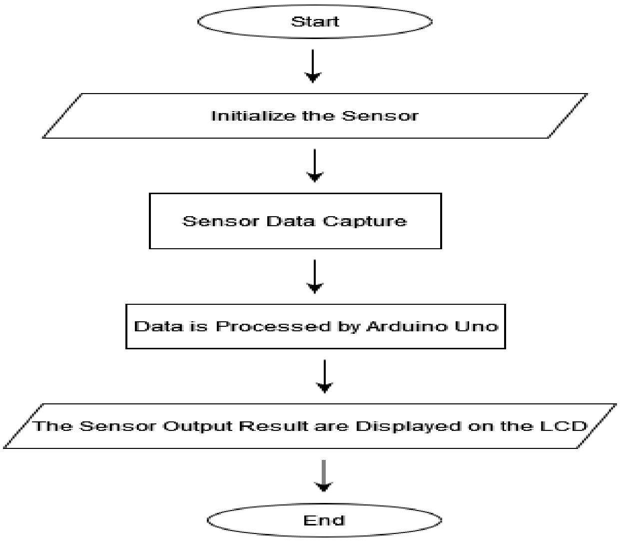

Fig 4. Research Flowchart

Based on Figure 4, the flow of the software can be explained using the Arduino IDE software. Initially, initialization of the sensor used was carried out, then data was collected from the pH sensor, DS18B20 temperature sensor, and turbidity sensor. Then the data obtained was processed by Arduino and the output value from the sensor will be displayed by the LCD used.

After the components to be used have been designed, then a tool is made from the pond water quality monitoring system with the aim that when testing the tool can be seen whether the tool designed is running properly or not. This tool can also be used to perform data retrieval for processing. Data collection is carried out using a system that has been designed and each sensor that makes up the system will be dipped into the fish pond.

The last step taken from this research is to test the tools that have been made. The purpose of testing this tool is to ensure that the tool that has been designed can run properly as needed. Data collection is carried out using three sensors, namely data regarding the acidity of pond water which is carried out using a pH sensor, water temperature data on the edge of the pond using a DS18B20 temperature sensor, and measuring the turbidity of water in the pond will be carried out using a turbidity sensor. The data obtained from the sensor used will be displayed on the LCD.

III. RESULTS AND DISCUSSION

Based on the data obtained, it can be seen from the specifications of the components used. Tool analysis of the data obtained is in the form of performance specifications and tool design specifications. The presentation of the data obtained is expressed in the form of tables and graphs. The specifications were made during the research, namely, the series of sensors used. The circuit of each component used is shown in Figure 5.

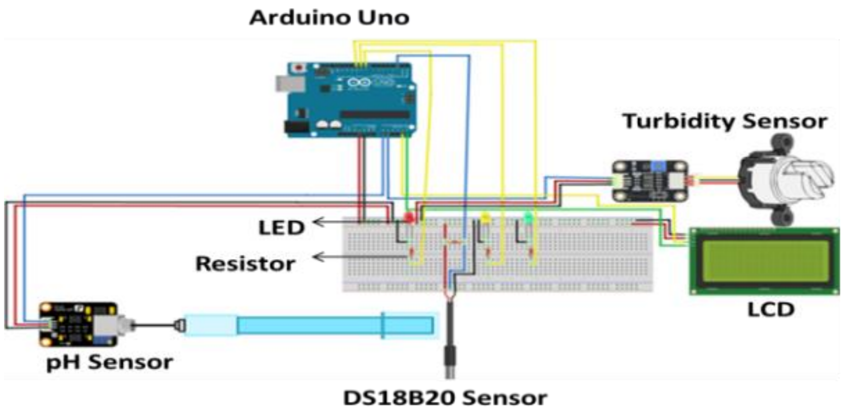

Fig 5. Display the finished image in the tool instead of the design

Figure 5 shows the arrangement of the sensors used in this system. This system has 3 sensors, 3 LEDs, and an LCD to display the output of the sensors. The pH sensor is used to measure physical quantities. This sensor has 3 pins, namely the GND (ground) pin, the input pin, and the data pin. In this system, the input pin used will be connected to the 5-volt pin. The sensor ground pin is connected to the ground pin on Arduino Uno and the data pin on the sensor is connected to pin A1 on Arduino Uno.

Next is the DS18B20 temperature sensor. The DS18B20 temperature sensor is a digital sensor used to measure the temperature of fish pond water. The DS18B20 temperature sensor has 3 pins, namely the GND (ground) pin, the input pin, and the data pin. The ground pin on the sensor is connected to the ground pin on the Arduino Uno, the sensor input pin is connected to the 5-volt pin on the Arduino Uno, and the data pin on the sensor is connected to the D2 pin on the Arduino Uno. To assemble this sensor, 1 resistor with a value of 4.7 K is needed to connect the input pin and the data pin.

Finally, the turbidity sensor is used to measure the turbidity of fish pond water. A turbidity sensor is a sensor that is digital and analog. So that the use of this sensor can be done in the form of analog output or digital output. The turbidity sensor consists of 3 pins, namely the GND (ground) pin on the sensor which is connected to the Arduino Uno ground pin, the input pin on the sensor is connected to the 5-volt pin and the data pin on the sensor is connected to pin A0 on the Arduino Uno.

This system uses 3 LEDs to give a warning if the condition of the fish pond water is dangerous to the fish. The LED will turn on when the condition of the pond water is above the conditions that have been set. While the LCD in this system is used to display the output of each sensor used. The display of the instrument box can be seen in Figure 6.

(a) (b) (c)

Fig 6. (a) Front view, (b) Outer view, and (c) Inside view of the measuring instrument

Figure 6 is a view of the front, rear, and inside of the instrument box. The instrument box contains the essential components used to run the system. Components used, such as the Arduino Uno microcontroller, sensors used, LEDs, and LCD, will be arranged in an instrument box with a size of 12.5 cm x 8.5 cm x 5.5 cm.

This design specification consists of the characteristics, accuracy, precision, and measurement of fish pond water quality. The purpose of performing sensor characteristics is to obtain accurate sensor readings when compared with readings from standard tools [14]. The characteristics of the pH sensor are obtained from the effect of changing the pH value on the ADC value of the pH sensor. From the data obtained, it is known that the greater the measured pH value, the greater the ADC sensor value obtained.

The characteristics of the DS18B20 temperature sensor are obtained through the relationship between the ADC sensor value and the value of the thermometer. This value is obtained by heating the water, which is then measured with a thermometer and the sensor itself. From the data obtained, it is known that the temperature values obtained are comparable to the standard tools used. The higher the temperature on the thermometer, the temperature read by the sensor will also be higher [15].

Furthermore, the characteristics of the turbidity sensor are obtained from a comparison of the ADC sensor with the reference used. The reference value is water, whose turbidity value is known in NTU units. Where the value of the ADC sensor is proportional to the turbidity value of the reference used. The more turbid the pond water, the turbidity level that will be read by the sensor will also increase [16]. The data obtained from sensor characteristics will be presented in the form of a regression curve.

The expected accuracy of the instrument is the measurement value of the standard and the measuring instrument used does not have too much difference. The closer the value obtained by the sensor used with the standard tool, the more accurate the tool is declared. The accuracy of the tool will be sought on each sensor used. The sensors used are a pH sensor, a temperature sensor DS18B20 and a turbidity sensor.

Accuracy data on each sensor is measured 10 times by varying the measurement value, which will then be compared with a standard measuring instrument. The following data on the accuracy of the condition of the pH of fish pond water was obtained as shown in Table 1.

Table 1. Data on the accuracy of the pH sensor

No	Standard Tool	Measuring Instrument	Accuracy	% Error
1	7,07	6,75	0,955	4,5

2	6,38	6,31	0,989	1,1
3	5,86	5,88	0,997	0,3
4	5,15	5,05	0,98	2
5	4,78	4,45	0,93	7
6	4,62	4,34	0,94	6
7	4,44	4,07	0,92	8
8	4,35	4,02	0,93	7
9	4,28	3,96	0,93	7
10	4,23	3,91	0,93	7
	Average		0,95	4,99

Data on the accuracy of the DS18B20 temperature sensor can be seen in Table 2.

Table 2. Accuracy data of the DS18B20 temperature sensor

No	Standard Tool	Measuring Instrument (°C)	Accuracy	% Error
1	7,07	6,75	0,955	4,5
2	6,38	6,31	0,989	1,1
3	5,86	5,88	0,997	0,3
4	5,15	5,05	0,98	2
5	4,78	4,45	0,93	7
6	4,62	4,34	0,94	6
7	4,44	4,07	0,92	8
8	4,35	4,02	0,93	7
9	4,28	3,96	0,93	7
10	4,23	3,91	0,93	7
	Average		0,95	4,99

The measurement results regarding turbidity sensor accuracy will be compared with the standard equipment used in the form of water whose turbidity value is known in Table 3.

Table 3. Turbidity sensor accuracy data

No	Standard Tool (NTU)	Measuring Instrument (NTU)	Accuracy	% Error
1	10	9,28	0,928	7,2
2	20	20,21	0,989	1,05
3	30	31,13	0,962	3,77
4	40	42,05	0,95	5
5	50	52,98	0,94	5,96
6	60	58,44	0,974	2,6
7	70	63,9	0,913	8,7
8	80	80,28	0,996	3,5
9	90	91,21	0,987	1,3
10	100	102,13	0,978	2,1
	Average		0,9419	4,118

Accuracy is the closeness of the value of a measuring instrument to a standard tool. If the value obtained by the sensor is close to the actual values then the sensor can run properly [17]. The measurement of sensor accuracy was carried out 10 times. The accuracy measurement is divided into 3 parts, namely, the average measurement accuracy of the pH sensor is 0.95, or if it is a percentage, it becomes 95 with an average error percentage of 4.99%. Then, the DS18B20 temperature sensor has an average accuracy of 0.97, or if it is used as a percentage, it becomes 97% with an average error of 2.97%, and on the turbidity sensor, the average accuracy is 0.9419, or if it is used as a percentage, it becomes 94.19% with an average error on the sensor that is 4.12%. From the accuracy value obtained, it can be seen that the tool used works well.

Instrument precision data can be obtained by measuring a parameter with a predetermined parameter value, then measuring the sensor used 10 times. From the experimental data carried out, it is expected that these measurements will get almost the same value so it can be said that the tool has a high level of precision. Precision data from the pH sensor is shown in Table 4.

Table 4. pH sensor precision data

Experiment to-	Value	Precision
1	3,52	0,994
2	3,52	0,994
3	3,52	0,994
4	3,52	0,994
5	3,47	0,992
6	3,47	0,992
7	3,52	0,994
8	3,52	0,994
9	3,47	0,992
10	3,47	0,992
Average	3,5	0,9932

Instrument precision data on temperature sensor are shown in Table 5.

Table 5. DS18B20 temperature sensor precision data

Experiment to-	Value (℃)	Precision
1	30.69	0,998
2	30,75	0,996
3	30,75	0,996
4	30,69	0,998
5	30,69	0,998
6	30,69	0,998
7	30,69	0,998
8	30,69	0,998
9	30,69	0,998
10	30,69	0,998
Average	30,633	0,9976

The results of measuring the precision of the turbidity sensor are shown in Table 6.

Table 6. Turbidity sensor precision data

Experiment to-	Value (NTU)	Precision
1	42.98	0,95
2	54.91	0.8
3	42.98	0.95
4	42.98	0,95

5	42.98	0.95
6	54.91	0.8
7	42.98	0.95
8	42.98	0.95
9	42.98	0.95
10	42.98	0.95
Average	45,358	0,92

Precision is the value of a measuring instrument that has little uncertainty [17]. For sensor precision data, it is also divided into 3 parts. The pH sensor has an average precision of 0.9932, or if used, a percentage of 99.32%. Furthermore, the DS18B20 temperature sensor has an average precision of 0.9976 or a percentage of 99.7196%, and the precision of the turbidity sensor has an average accuracy of 0.9726 or a percentage of 97.26%.

The next research is the measurement of fish pond water quality. Data collection was carried out at BBI Nagari Pagaruyung, Tanjung Emas District, Tanah Datar. The measurement data was carried out by measuring all parameters, namely, pH, temperature, and turbidity. Data collection by the measuring instrument is carried out every 2 minutes, and data collection is carried out for 4 hours. If the data taken exceeds the tolerance limit that has been set, then the LED used will turn on to give a warning. Figure 7 is the measurement data for each parameter that was carried out.

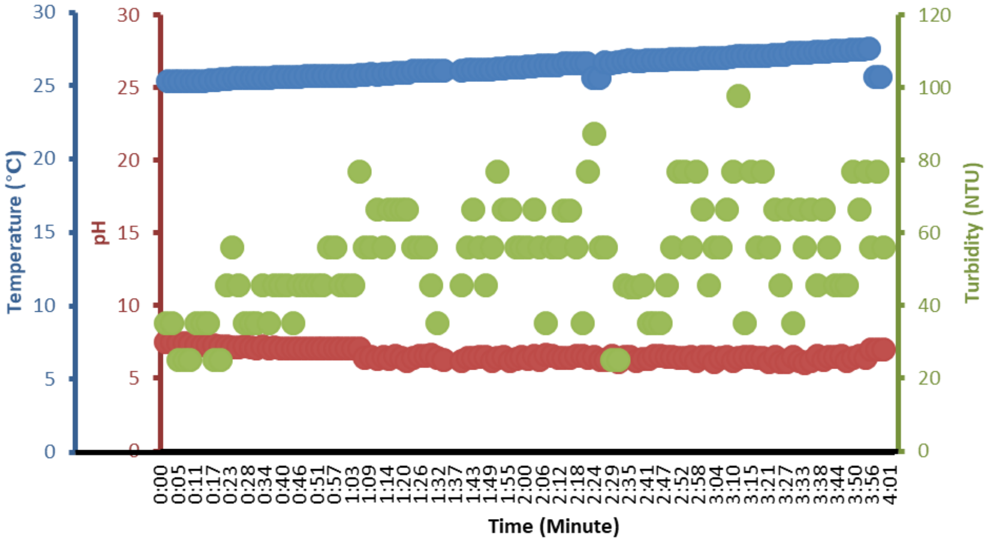

Fig 7. Graph of measurement results on the system

Figure 7 is the result of measurements carried out over 4 hours. From each parameter measured, the average of each sensor used was obtained, namely for the pH sensor was 6.61, the temperature sensor was 26.28 ℃, and the turbidity sensor was 52.8864 NTU.

From the measurements, the lowest temperature was 25.31 ℃ and the highest temperature was 27.56 ℃. High temperatures in fish will cause fish to be infected with viruses and bacteria, and if the temperature is low it will cause a decrease in body immunity. Temperature changes can be caused by several factors, such as sunlight, air temperature, weather, and climate [18].

Furthermore, the lowest pH measurement was 6.05, and the highest pH was 7.52. Changes in pH are affected by changing turbidity levels which cause pond water to become acidic or alkaline. An increase or decrease in pH can be caused by excessive feeding lack of appetite for fish which causes decomposition of fish feed to produce carbon dioxide, and increased levels of ammonia in the water [19]. Meanwhile, if the pH value is not optimal, it will cause fish to become stressed, susceptible to disease, and low productivity and growth. In aquaculture, pH plays an important role because it relates to the ability of fish to grow and reproduce [6].

Whereas for fish pond turbidity, the lowest turbidity value is 24.8942 NTU, and for the highest turbidity is 97.4899 NTU. Measuring the turbidity of pond water is difficult to do because it is subjective. After all, so far, the principle of light scattering is still used to measure the turbidity of water. In collecting data, this sensor is closed by using a pipe to prevent light from entering. Because the turbidity sensor is a sensor that is very sensitive to light in the surrounding environment, causing instability [20]. The change in the value of the turbidity sensor is caused by a large number of dissolved particles, such as leftover feed and fish waste, which causes the received light intensity to decrease, resulting in a change in the sensor output voltage [7], which is also supported by [1] Wadu, et al, 2017 who stated that on the turbidity sensor, the resulting output voltage would change as the water turbidity level increases.

IV. CONCLUSION

The result of the Arduino Uno-based tilapia pond water quality monitoring system is an innovative solution that allows effective and real-time monitoring of tilapia pond water quality. By using affordable and easily accessible Arduino hardware, it can help fish farmers to monitor water temperature, pH and pond water turbidity. Apart from that, it also provides flexibility in providing warnings if there are drastic changes in water quality parameters, so that corrective action can be taken quickly.

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