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Automation of water circulation regulation and nutritional administration in catfish cultivation ponds with Biofloculation technology

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ABSTRACT

Many catfish cultivators in Indonesia have failed due to lack of attention to the quality of the water used in aquaculture ponds. Water quality is very influential on the catfish farming system with biofloc technology, water has the most important role for the survival of catfish. This research periodically measures the level of turbidity and pH in the water, then the readings from the sensor will be processed by Arduino Uno which will be displayed on the LCD. In addition, this tool can also schedule the provision of nutrients as desired and is able to perform automatic water changes according to the conditions of the aquaculture pond, if the pH and turbidity conditions of the pond exceed the existing threshold, it will activate the drain pump and water increase. The accuracy of the acidity (pH) sensor has an accuracy rate of 96.21% which is very good, with a standard deviation of 2.49. The turbidity sensor has a standard deviation of 0.133. So this tool is designed to make it easier for cultivators to take care of the pond. The hope is that by making this tool it can overcome or overcome the mortality rate of catfish among cultivators.

1. Introduction

The increasing number of catfish farmers in Indonesia are experiencing failure due to the high mortality rate of catfish due to a lack of attention to the quality of the water used in aquaculture ponds. Until now conventional catfish farming techniques have a relatively high mortality rate for catfish seeds, reaching 10-20%, with fermentation and probiotic techniques, the mortality rate for catfish is smaller and can be reduced to <5% from the previous value [1]. However, the cultivation of freshwater fish, especially catfish, is increasing with an average increase of 26.43% per year [2]. The technology for cultivating catfish using the biofloc system itself is a solution for people who want to cultivate catfish but are limited by land, because the cultivation of the biofloc system can use barrel or tarpaulin ponds, or in limited places because we don't know how. Biofloculation technology is a wastewater treatment technology that uses the activity of biological microorganisms to increase carbon and nitrogen in water [3]. Biofloc is a technology currently being developed in aquaculture which aims to improve water quality and increase the efficiency of nutrient utilization. Probiotics themselves work by controlling the development and number of harmful microbes, creating an optimal growth environment for beneficial microbes until finally these microbes dominate and make a more suitable habitat for organisms in that environment to grow. This is because the floc formed in the biofloc cultivation system contains high protein which can increase the growth rate of fish [4].

Water quality including TAN, ammonia, nitrite, nitrate, COD, temperature, DO, and pH as well as total bacterial solids have an important role in describing the environmental conditions of a waters, especially the cultivation environment [5]. The success of aquaculture is reflected in high production and low mortality rates. The use of probiotics is able to improve water conditions so that they become an alternative for fish farmers today. Probiotics are additional food (supplements) in the form of live microbial cells that have a beneficial effect on the host animal that consumes them through balancing the intestinal microorganism flora in the digestive tract [6]. The condition of water as a living medium for aquatic biota must be adapted to optimal conditions for the biota being reared. The quality of the water includes the quality of physics, chemistry and biology. Physical factors such as temperature, brightness and depth. Chemical factors include pH, DO, CO2 and NH3 [7]. The tools made can speed up the process of checking the temperature and pH of the water, can make it easier for fish cultivators to know the temperature and pH values of water continuously, can make it easier for fish cultivators to quickly neutralize the temperature and acidity of the water solution (pH), can control temperature and acidity of the water solution (pH) automatically [8].

Monitoring tools are very often used in various fields, one of which is in the field of fisheries, with the aim of making it easier for the owner or to make it easier in terms of monitoring pond conditions and reducing the behavior of human errors, there are also many who use pH sensors and turbidity sensors as indicators to monitor pond health. Monitoring tools for measuring acidity, turbidity and temperature values can be carried out using the Atmega-2560P sensor and microcontroller and for sending data using the RF433Mhz module [9]. A tool for monitoring is often used in various ways, especially in terms of sending sensor readings, some of which are turbidity sensors and salt level sensors. Measurement of the value of salt content can be done using a sensor and AT89S51 microcontroller [10]. Arduino Uno can be used for multiple sensors at once, Arduino Uno can be used to access 6 sensors for reading analog values with an accuracy of up to 1024 bits [11]. The level of water turbidity is measured by utilizing the change in sensor voltage due to changes in turbidity. The designed device is capable of taking measurements in real time and displaying them in numbers and storing them in database form [12]. The turbidity meter is used to measure the turbidity of water with the influence of the intensity of the transmitted light. When a light beam hits a medium with scattering particles, most of the light will be transmitted or transmitted and some will be scattered in all directions randomly by the particles. The scattered LED light is then used as the basis for measurement [13]. This research was made and designed, namely a tool for providing nutrition (probiotics) automatically and monitoring water conditions, namely pH and turbidity based on Arduino Uno. This tool is designed automatically to make it easier to provide nutrition (probiotics) to fish according to a predetermined schedule. With the hope of reducing and minimizing the mortality rate of catfish among cultivators.

2. Method

2.1 Theoretical framework

The research method is the steps that can be taken to solve problems that occur when conducting research by following the rules carried out by researchers so that the desired goals can be achieved and get good results [14]. Catfish have a body shape that is different from other fish, so it can be easily distinguished from other types of fish. The catfish has an elongated body shape, flat head, no scales, has four pairs of elongated whiskers as a touch tool, and has an additional breathing apparatus (larborescent orgon) [15].

The pH sensor is used to determine the degree of acidity or alkalinity of a solution. Measurement and control of pH is very important for various chemical and biological studies in laboratories and various industrial fields [16]. Turbidity Meter is a waste water testing tool that functions to measure the level of turbidity of water. Turbidity meters are also called water turbidity meters. As we know, there are many causes of water pollution around us, for example, household, industrial, agricultural, livestock waste water, and many more [17].

Arduino Uno is a type of board (board) containing a microcontroller the size of a credit card which is equipped with a number of pins used to communicate with other equipment. Arduino is a versatile microcontroller that allows programming. Programs on Arduino are usually called sketches. Arduino is "an open source platform used to create electronics projects". Arduino consists of two main parts, namely a physical circuit board which is often referred to as a microcontroller and a software or IDE that runs on a computer as a compiler [18]. The RTC (Real-Time Clock) is a battery-powered clock included on a microchip in a computer's motherboard. These microchips are usually separate from other microprocessors and chips and are often referred to as "CMOS" (complementary metal oxide semiconductor [19].

2.2 Block Diagram

Block diagram is a part of the principle and performance of a system in making a tool design. The overall workings of a tool that will be made lies in the system block diagram [20]. The various materials or components used in this study can be seen in Fig. 1. This study used the ATmega328P microcontroller packaged in the form of a microcontroller board, namely Arduino Uno R3. Arduino Uno R3 was chosen because this board has a lot of compatibility with various types of sensors and other modules. This study uses several components and modules such as Arduino, turbidity sensor, pH sensor, RTC, mini pump, adapter, and LCD, the block diagram is shown in Fig. 1.

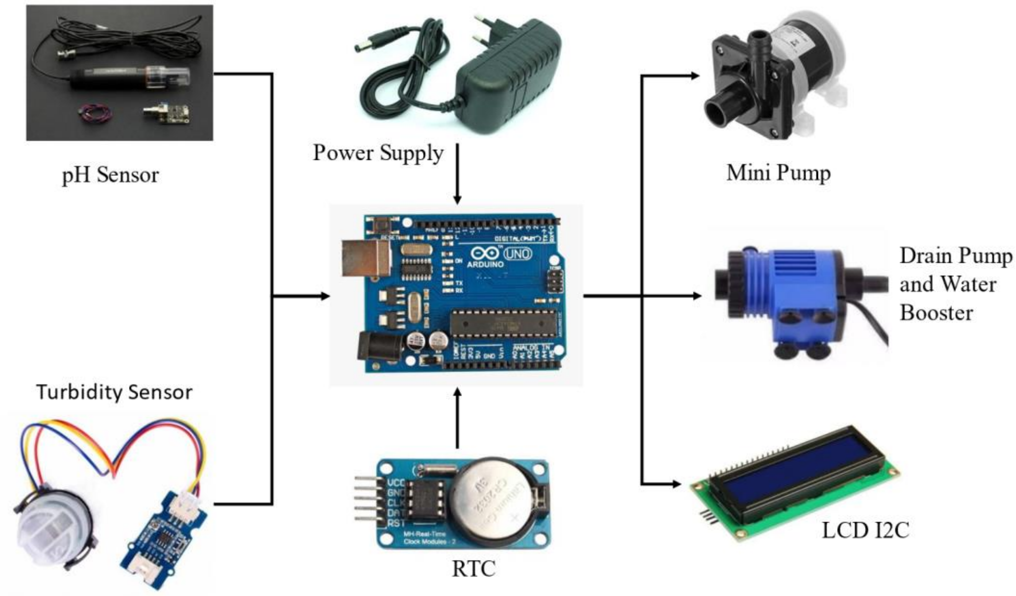

Fig. 1. Block diagrams

The input generated by the sensor used is in the form of an analog voltage, so the analog value needs to be changed first to a digital voltage. ADC or Analog to Digital Converter is one of the features found on Arduino Uno R3, on this board there are 6 ports that can be used to convert analog voltage to digital.

2.3 Flowchart

A flowchart or often referred to as a flowchart is a type of diagram that represents an algorithm or sequential instruction steps in a system [21]. This tool has two work systems. The first tool will automatically every day and the tool can perform water changes automatically according to pool conditions. The flowchart for this hardware is shown in Fig. 2.

Besides that, this tool will also automatically spray and replace water automatically when the turbidity sensor module detects the level of water turbidity and the pH sensor detects a pH that exceeds the threshold for water turbidity and a pH that can be tolerated by catfish in the pond. The tool will automatically activate the water pump at the bottom of the pond to suck up water and fish waste at the bottom of the pond to be sucked out of the fish pond and also turn on another pump to add clean water which will be flowed into the aquaculture pond as a substitute for the water that has been drained. sucked out of the pool. In addition, this tool also has an automatic nutrition scheduling system according to what we want, as shown in Fig. 3.

In this study the tool will carry out scheduling in the form of spraying nutrients (probiotics) into aquaculture ponds with a schedule of 3x a day with certain doses according to the needs of the fish. The researcher used Eagle version 6.4 to make a PCB layout for this prototype, first the researcher made a schematic then brought the schematic to the layout board and made a PCB design there, the schematic is shown in Fig. 4.

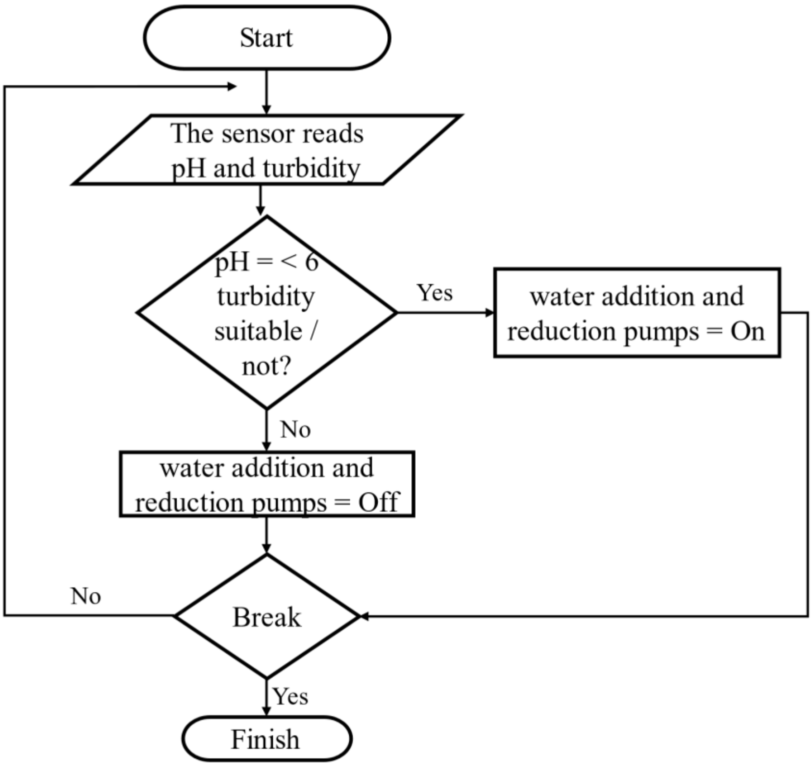

Fig. 2. Flowchart of water circulation control system with pH sensor and turbidity (turbidity)

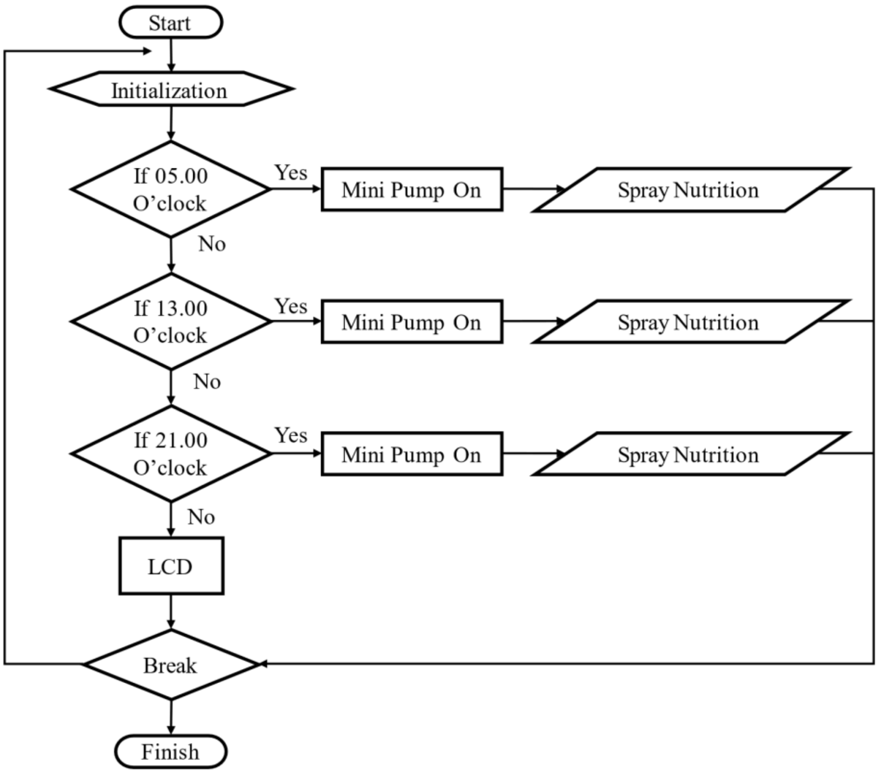

Fig. 3. Flowchart of nutrition delivery scheduling system

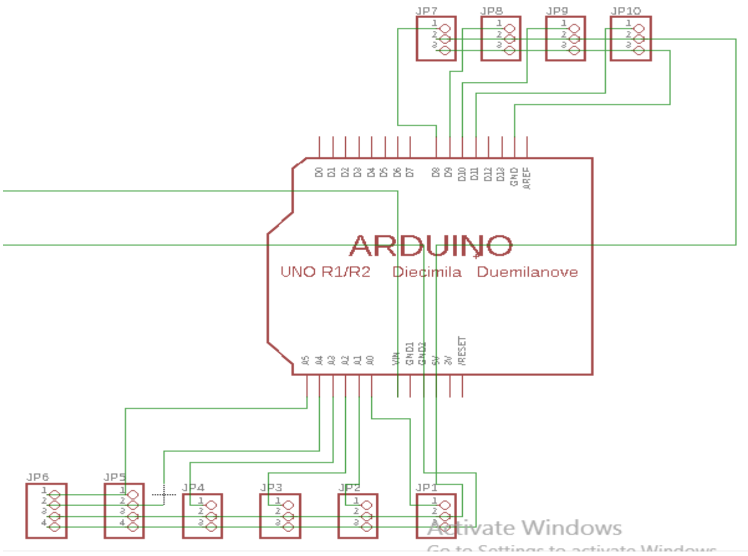

Fig. 4. Mini system schematic

3. Results and Discussion

3.1. Turbidity Sensor Testing

Testing of the turbidity sensor is carried out by dipping a portion of the sensor into the aquaculture pond water with a bioflocculation system. The turbidity sensor test can be seen in Fig. 5, the turbidity sensor test results can be seen in Table 1. and the test graph can be seen in Fig. 6.

Fig. 5. Turbidity sensor testing

Table 1. Turbidity sensor test results

No	Turbidity (NTU)	Condition Turbidity	Condition Drain Pump
1	37	Enough	OFF
2	40	Enough	OFF
3	42	Enough	OFF
4	44	Enough	OFF
5	39	Enough	OFF
6	41	Enough	OFF
7	38	Enough	OFF
8	43	Enough	OFF
9	41	Enough	OFF
10	38	Enough	OFF

In testing the validity of the turbidity measuring device the researcher searched for the average value using Equations (1), (2) and (3), in this experiment 15 trials were carried out as shown in Table 2.

$$\bar{x} = \frac{1}{n} + \sum_{i=1}^{n} x_i \tag{1}$$

$$\bar{x} = \frac{37+40+42+44+39+41+38+43+41+38+41+43+45+42+46}{15} = 41.33$$

Table 2. Calculation of standard deviation of turbidity sensor measurements

i	x_i	$\bar{x}$	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
1	37	41.33	-4.33	18.78
2	40	41.33	-1.33	1.78
3	42	41.33	0.67	0.44
4	44	41.33	2.67	7.11
5	39	41.33	-2.33	5.44
6	41	41.33	-0.33	0.11
7	38	41.33	-3.33	11.11
8	43	41.33	1.67	2.78
9	41	41.33	-0.33	0.11
10	38	41.33	-3.33	11.11
		Total		97.33

$$\bar{x} = \frac{1}{n} + \sum_{i=1}^{n} x_i \tag{2}$$

$$\bar{x} = \frac{37+40+42+44+39+41+38+43+41+38+41+43+45+42+46}{15} = 41.33$$

$$x = \sqrt{\frac{1}{N-1} + \sum_{i=1}^{N} (x_i - \bar{x})^2} \tag{3}$$

$$\mathrm{s}^2 = \frac{1}{15-1} \times 97.33$$

$$\mathrm{s}^2 = 6.95$$

Then the researcher looks for the standard deviation value from the results of the variant value, then the standard deviation value is obtained as Equation (4).

$$\mathrm{s} = \sqrt{\mathrm{s}^2}$$

$$\mathrm{s} = \sqrt{6.23} \tag{4}$$

$$\mathrm{s} = 2.49$$

Sensor testing in the morning. The standard deviation value is 2.49 and close to 0 indicates that the sensor is working properly. From the data in Table 2 shows a graph of the reading results from the sensor test. The graph of the standard deviation of the sensor during the day can be seen in Fig. 6. You can see the sensor readings and the standard deviation value with

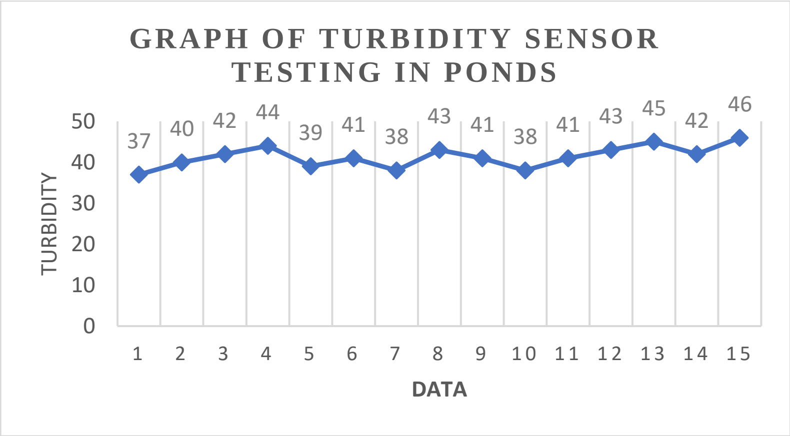

Fig. 6. Graph of turbidity sensor measurement results

3.2. pH Sensor Testing

In this test, 2 measurements will be carried out, namely with a pH sensor and with a calibrated pH meter. pH measurements with this pH sensor will be carried out 15 times. pH measurement with a pH meter will also be carried out in the pond 15 times. So that at the time of data processing it is necessary to carry out an operation to find the average value of 15 pH measurement experiments. In this study the value obtained by the pH meter will be used as a reference for the accuracy of the sensor using Equation (5).

Fig. 7. pH sensor testing

Table 3. Turbidity sensor test results

No	pH Sensors	pH Condition	pH Meter	Drain Pump Condition
1	6.8	Good	7.2	OFF
2	6.9	Good	7.3	OFF
3	6.7	Good	6.9	OFF
4	6.8	Good	7.0	OFF
5	7.0	Good	7.1	OFF
6	6.7	Good	7.3	OFF
7	7.1	Good	7.2	OFF
8	6.9	Good	6.8	OFF
9	6.8	Good	7.4	OFF
10	6.7	Good	7.0	OFF

$$\bar{x} = \frac{1}{n} + \sum_{i=1}^{n} x_i \quad (5)$$

Average pH sensor:

$$\bar{x} = \frac{6.8 + 6.9 + 6.7 + 6.8 + 7.0 + 6.7 + 7.1 + 6.9 + 6.8 + 6.7 + 6.9 + 6.8 + 7.0 + 7.1 + 6.9}{15}$$

$$\bar{x} = 6.87$$

Average pH meter:

$$\bar{x} = \frac{7.2 + 7.3 + 6.9 + 7.0 + 7.1 + 7.3 + 7.2 + 6.8 + 7.4 + 7.0 + 7.2 + 7.3 + 6.9 + 7.1 + 7.4}{15}$$

$$\bar{x} = 7.14$$

In this experimental process the measured average value (NT) is 7.14 while the actual average value (NS) is 6.87, so that the pH measurement accuracy is obtained as in Equation (6):

$$Accuracy = \frac{NT - NS}{NS} \; x \; 100\% \quad (5)$$

$$Accuracy = \frac{6.87}{7.14} \times 100\% = 96.21\%$$

The researcher then looked for the standard deviation or standard deviation from Table 4, so Table 4 was obtained. The graph obtained by the researcher is as shown in Fig. 8.

Table 4. Calculation of standard deviation of turbidity sensor measurements

i	**xi**	$\bar{x}$	**xi -** $\bar{x}$	**(xi -** $\bar{x}$ **)2**
1	6.8	6.87	-0.073	0.0054
2	6.9	6.87	0.027	0.0007
3	6.7	6.87	-0.173	0.0300
4	68	6.87	-0.073	0.0054
5	7.0	6.87	0.127	0.0160
6	6.7	6.87	-0.173	0.0300
7	7.1	6.87	0.227	0.0514
8	6.9	6.87	0.027	0.0007
9	6.8	6.87	-0.073	0.0054
10	6.7	6.87	-0.173	0.0300

$$x = \sqrt{\frac{1}{N-1} + \sum_{i=1}^{N} (x_i - \bar{x})^2} \quad (6)$$

$$s^2 = \frac{1}{15 - 1} \times 0.2493$$

$$s^2 = 0.0178$$

$$s = \sqrt{s^2}$$

$$s = \sqrt{0.0178}$$

$$s = 0.133$$

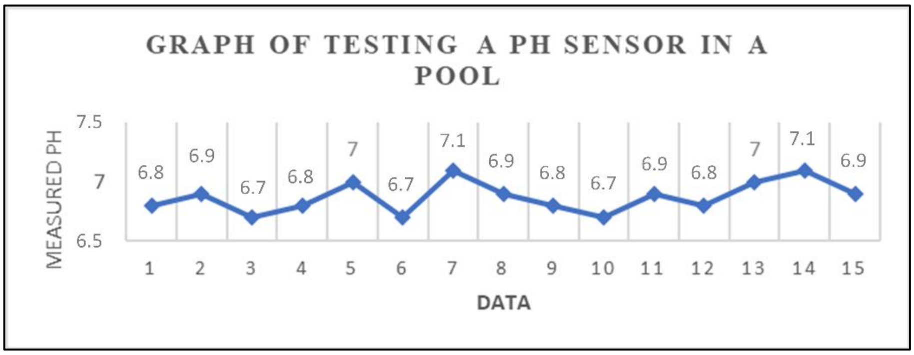

Fig. 8. Graph of pH sensor testing

Graph of sensor standard deviation Fig. 8. shows the results of sensor readings and the standard deviation value close to 0 indicates that the sensor is working properly. This means that there is still some data that is fluctuating and less linear and has not worked very well but has managed to retrieve and read data.

3.3. Testing of Drain Pumps and Water Additions

Testing to see whether the drain pump is working or not is monitored every 5 minutes as shown in Fig. 9. Because the drain pump can work (ON) at any time according to the conditions in the pond. such as when the pH is too high or the pH is too low and it can also work (ON) because the turbidity level exceeds the threshold. . The test results to see if the drain pump is working or not are as shown in Table 5.

From Table 5 it can be observed that the automatic pond drain pump is in the OFF condition because the pH and turbidity are still at the threshold that can be tolerated by catfish. The turbidity threshold that can still be tolerated by catfish is 50 NTU and catfish can still live at a pH of 5 - 10.

Fig. 9. pH sensor testing

Table 5. Test results data to see the drain pump

No	Time	Drain Pump Condition	Explanation	
1	14.25	OFF	pH = 7.2	NTU = 37
2	14.30	OFF	pH = 7.3	NTU = 40
3	14.35	OFF	pH = 6.9	NTU = 42
4	14.40	OFF	pH = 7.0	NTU = 44
5	14.45	OFF	pH = 7.1	NTU = 39
6	14.50	OFF	pH = 7.3	NTU = 41
7	14.55	OFF	pH = 7.2	NTU = 38
8	15.00	OFF	pH = 6.8	NTU = 43
9	15.05	OFF	pH = 7.4	NTU = 41
10	15.10	OFF	pH = 7.0	NTU = 38

3.4. Testing of Nutrition Delivery Pump Scheduling

Testing the scheduling of pumps for providing nutrition is carried out with the aim of knowing the accuracy of pump scheduling in terms of providing nutrients to fish farming ponds. The pump for providing nutrients every day will carry out scheduling (pump ON) for 3 times a day, but for testing the scheduling of providing nutrition this time is done every 2-5 minutes according to the program we entered to find out the level of accuracy of the tool. The results of testing the scheduling of the pump for providing nutrition are as shown in Table 6 and the sensor test graphs are as shown in Fig. 10.

Fig. 10. Testing the scheduling of the feeding pump

Table 6. Data on the results of scheduling pumps for providing nutrition

No	Time	Nutrition Delivery Pump Conditions
1	14.24	ON
2	14.26	ON
3	14.29	ON
4	14.33	ON
5	14.37	ON
6	14.39	ON
7	14.42	ON
8	14.55	ON
9	15.05	ON
10	15.09	ON

In this test, the scheduling of the nutrition pump is very precise and accurate as can be seen from the graph above, when we enter the scheduling command at the time we have specified, the nutrition pump will turn on (ON) and on time. This proves that the work of the tool is appropriate and accurate as expected.

4. Conclusion

An automation tool for regulating water circulation and providing nutrition in catfish farming ponds using bioflocculation technology has been successfully created.Based on the test results and observations from the automation of water circulation regulation and nutrition in catfish farming ponds using bioflocculation technology, the accuracy of the acidity (pH) sensor has an accuracy rate of 96.21% which is very good, with a standard deviation of 2.49. It's just that for the turbidity sensor the accuracy is unknown because there is no water turbidity meter as a reference for comparison with the turbidity sensor with a standard deviation of 0.133. The program for making automation tools for regulating water circulation and providing nutrition in catfish farming ponds uses the Arduino IDE software.

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