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Design of Turbine Aerator with Remote Control and Internet of Things (IoT)-Based Water pH Monitoring

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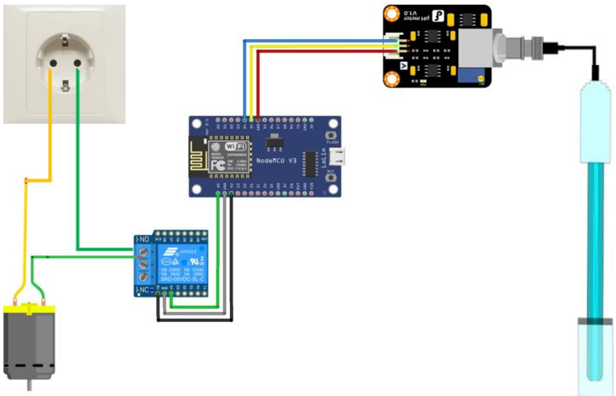
ABSTRACT



Water plays a very important role for living things including fish, with good water fish can grow optimally and healthily. The acidic and alkaline content of water and also oxygen greatly affects its growth. Currently, the majority of fish farmers monitor the pH and oxidation process of the pond manually. Therefore, in an aquaculture business, water quality must be monitored by fish farmers. In this research, an internet of things (IoT) based tool will be made that will produce oxygen in the water in tilapia ponds and is equipped with a pH sensor that will read how much pH value is contained in it, then the data can be viewed remotely via a cellphone connected to the internet. The telemetry system of this aerator research uses the NodeMCU ESP8266 microcontroller then the pH sensor reading data can be seen through the cellphone with the Blynk application as well as the aerator control can be easily done from the application. fish farmers can easily monitor the quality of water pH in real-time as well as control the aerator. The results achieved by the aerator can cause the oxidation process (dissolved oxygen) in water from the rotation of the impeller. Testing was carried out on a tilapia pond with a pond diameter of 15m2. The methodology used is quantitative with the results obtained from 10x experiments and comparison of the pH sensor and also the pH meter shows 96% accuracy of the pH sensor 4502C while 4% for the error value. the pH value before the aerator is active is 6 which means acidic. After the aerator is active and the dissolved oxygen process runs the pH value of the water becomes 7-7.5 which means neutral, this value is good for freshwater fish to breed well. from the help of this tool, fish farming farmers can more efficiently monitor water pH and aerator control.

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1. INTRODUCTION

Freshwater consumption fish is a fish that is quite well known among the people of Indonesia [2]. So that freshwater fish farming such as tilapia, catfish, and so on has also become one of the livelihoods for the community because it has a high economic value for the community's economy [1]. Freshwater fish farming is highly dependent on water conditions because healthy fish growth requires clean, nutrient-rich water. To ensure high water quality in freshwater fish farming, several things must be considered. For fish to develop healthily, the pH of the water must be balanced. A pH level between 6.5 and 8.0 is ideal for pond fish farming [3]. Dissolved oxygen in the pond is needed for the fish to survive. For breeding freshwater fish, an oxygen level of 5-7 ppm is ideal. Good quality water supports fish growth [3]. Fish need sufficient oxygen in the water to breathe and process the food they eat. If the water quality is poor, the oxygen level in the water may decrease and waste that is not digested by the fish may result in a buildup of waste and bacteria, which can affect the health of the fish and their growth [4]. In addition, poor-quality water can affect the pH level of the water, water temperature, salt content, and water turbidity [5]. All these factors can affect the health and growth of fish and can trigger the development of diseases in fish. Thus, maintaining good water quality in an aquarium or fish pond is essential for maintaining fish health and growth. This can be done by changing the water regularly, installing a good water circulation system, and conducting regular water tests to monitor water quality and adjust water conditions if necessary [6].

Water quality parameters that are commonly measured to monitor fish health and environmental conditions are temperature, pH, and DO (Dissolved Oxygen) [7]. The suitable water temperature for most fish ranges from 22°C to 28°C, depending on the type of fish and their environment. Temperatures that are too low or too high can affect fish metabolism and impair their growth and reproduction [1]. DO (Dissolved Oxygen): Dissolved oxygen in water is essential for fish life. The ideal amount of dissolved oxygen for fish is between 5 to 7 ppm (parts per million). If the dissolved oxygen level is too low, the fish may experience stress, die, or grow slowly [8].

Therefore, a system that can perform real-time monitoring is needed so that it can facilitate engineers in processing water quality monitoring data [9]. Aerators used by pond farmers today are generally still using a manual system, therefore to improve the quality of dissolved oxygen both in quality and quantity, this aerator design is equipped with an automatic controller [10]. In this research, a tool was made for tilapia fish ponds that are useful for reducing the potential mortality rate of fish caused by water quality which focuses on the oxidation process and the pH value contained, by designing an aerator to increase the level of dissolved oxygen. The novelty in this research is the real-time water pH telemetry system and remote aerator control. Internet of Things technology is used in this research. By using the NodeMCU Esp8266 microcontroller which is integrated with wifi internet. Control and monitoring of the pH of water can be done using a cellphone through the blynk application. This tool is expected for freshwater fish farming farmers to be able to monitor water pH and control aerators more efficiently.

2. METHODS

The action research method is used in this research by designing and developing an irrigation system in fish ponds that are used to overcome problems in fish farming. This research needs several steps so that the desired design can be achieved. The design of this tool is based on the internet of things (IoT), so the telemetry process and control can be done remotely using an internet connection. With the programming done in Arduino ide, microcontroller NodeMCU, and blynk become the place to do monitoring and control.

2.1. System Design

The design in the development of this tool is designed to be able to float on the surface of the water so that it requires a buoy. Using a pipe with a size of 4 dim and a length of 1 meter, and a buoy height with a 20cm chassis, while an ac motor with a speed of 2850rpm in the top position facing down directly opposite the impeller shaft that will enter the water with a depth of 15cm to be able to produce a mixture of water and oxygen (O2) which will be dissolved into water, such as the 3D design form in Figure 1 which shows the aerator turbine scheme. It works by introducing air into the water through a rotating turbine, which creates a water flow that promotes oxygen transfer and water mixing. Increased oxygen levels can support the growth of aerobic bacteria that help break down organic matter in the water, thereby reducing its pollutant content [11]. Turbine aerators consist of a propeller or impeller driven by an electric motor that rotates in the water, bringing air into the solution and generating turbulence that improves mixing and aeration. They are often used in wastewater treatment facilities to increase the concentration of dissolved oxygen in the water, which is necessary for organic wastewater treatment [12]. Aerators can also be used in aquaculture to supply fish and other aquatic life in ponds or containers with oxygen.

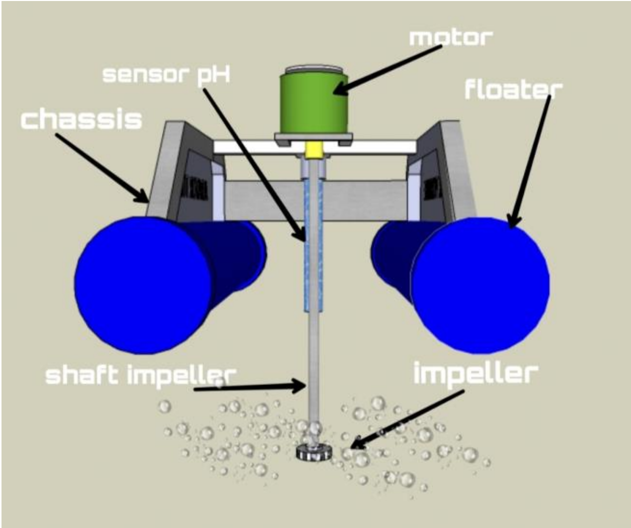

Figure 1. Aerator design

2.2. Wiring Design

Figure 2 shows the wiring circuit of the entire project that we made using the microcontroller NodeMCU 8266 where the pH sensor module component pin P0 is connected to pin D4 NodeMCU, pin GND (Ground) contained in the pH sensor module is connected to pin GND NodeMCU, then VCC Sensor Module pH connected to pin V + 3. 3v NodeMCU esp8266, then Relay functions as a switch connected to pin D4 connected to pin A0 NodeMCU, pin VCC to pin V + 5v NodeMCU, pin GND to pin GND NodeMCU ESP8266, then Relay Normally Close (NO) connected to the motor and PLN Power supply with 220v. Circuit readings can be made in Table 1.

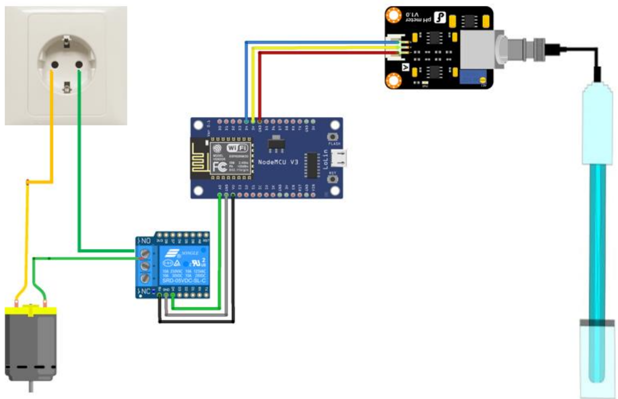

Figure 2. Wiring design

Table 1. NodeMCU port usage

Component	Pin Component	Board NodeMCU
Sensor pH	P0	D4
	GND	GND
	VCC	V+ 3.3V
Relay 5v	D4	A0
	VCC	V+ 5V
	GND	GND
	Normally Close (NC)	Power 220V

2.3. Block Diagram

Figure 3 shows the block diagram, before testing the tool, programming on the Arduino idea needs to be done so that the microcontroller can work properly according to the program that has been carried out, then make sure the tool is connected to 220V electric power and internet wifi network. Then the pH sensor takes readings of water [13]. The data obtained from the sensor readings will be sent to the NodeMCU 8266 microcontroller that has been programmed, the data is received and displayed to the blynk application on the android phone to control the relay as a switch of the 1-phase motor as a turbine impeller drive and the results of the pH sensor readings can be monitored easily in the blynk application.

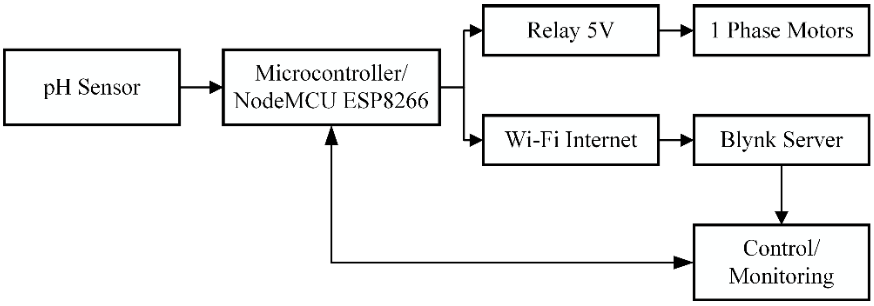

Figure 3. Block diagram

2.4. Flow Chart System

Figure 4 shows the flowchart of the aerator system, to run the tool the user opens the blynk IoT application with an internet connection range, the tool cannot run if the internet connection has not been connected. The pH sensor plays a role in detecting acidic or alkaline content in water [14]. The output generated from the sensor will be read digitally through the Blynk application, as shown in Figure 12, it can be seen, the numbers obtained from the pH sensor reading are sent to the Blynk application through the programming stage on the Arduino idea [15]. And also control the aerator if the user wants the aerator to be active click the "aerator on" button the motor will automatically move and the impeller will produce dissolved oxygen [16]. If the user presses the "aerator off" button the aerator will turn off. when the user presses the aerator on button then the aerator will not turn off if it does not press the aerator off button and vice versa.

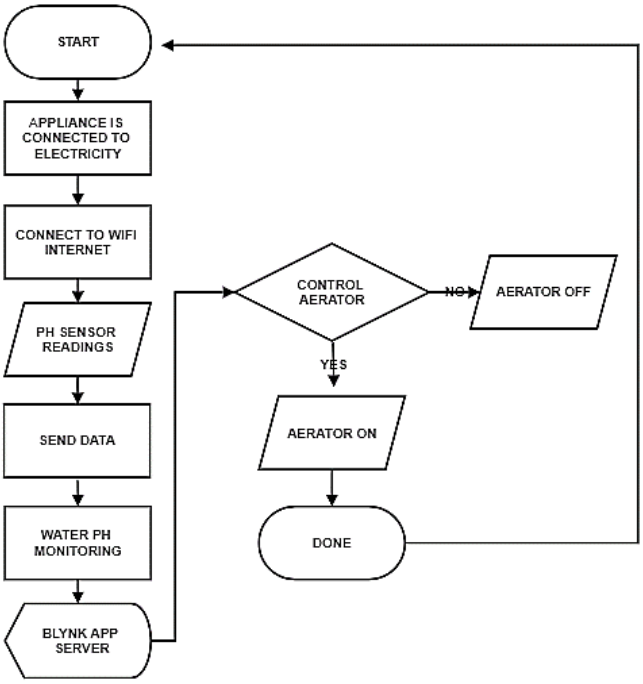

Figure 4. Flowchart system

2.5. Literacy Study

2.5.1. Dissolved Oxygen

Low dissolved oxygen causes more fish to die than any other cause of problems [17]. Like human breathing, fish need oxygen [18]. Water quality (WQ) maintenance refers to the characteristics of water (biological, physical, and chemical) to meet the various needs of water for living things [19]. The number of oxygen-consuming organisms in the water [20]. When water contains high concentrations of organic matter or nutrients such as phosphorus, it can be accompanied by a high pH (acid-base) balance and a list of saturated dissolved oxygen levels [21]. Oxygen is the essential element required for biological survival [22]. Therefore, in water quality management and aquaculture, dissolved oxygen is considered to be a key indicator off [23].

2.5.2. PH Sensor 4502C

A solution's acidity or basicity is determined by its pH [24]. The optimal pH range for freshwater fish is usually between 6.5 and 8.0. Freshwater fish typically thrive in water that has a slightly acidic to neutral pH, which is a measure of how alkaline or acidic the water is. The water pH will become too acidic if it is too low (below 6.5), which can stress the fish and jeopardize their growth and health. The biological balance of fish can be disrupted if the water pH is too high (above 8.0). However, keep in mind that each fish species has a preferred pH range, and that fish health is also affected by other elements such as temperature, dissolved oxygen, water quality, and nutrients. In this case, the water becomes too alkaline. using the 4502c pH sensor can measure water-soluble substances pH acidity or alkalinity. The pH value ranges from 1 to 14 with 7 being the neutral point value [25]. If the pH value is less than 7, it indicates acidity. On the other hand, if the pH value is greater than 7, it indicates alkanity [26]. Can be seen in the picture shows the 4502C pH meter module. The sensor readings will be sent to the microcontroller to be monitored through the blynk application on the mobile phone [27]. The sensor module display can be seen in Figure 5 and the pH sensor probe is in Figure 6.

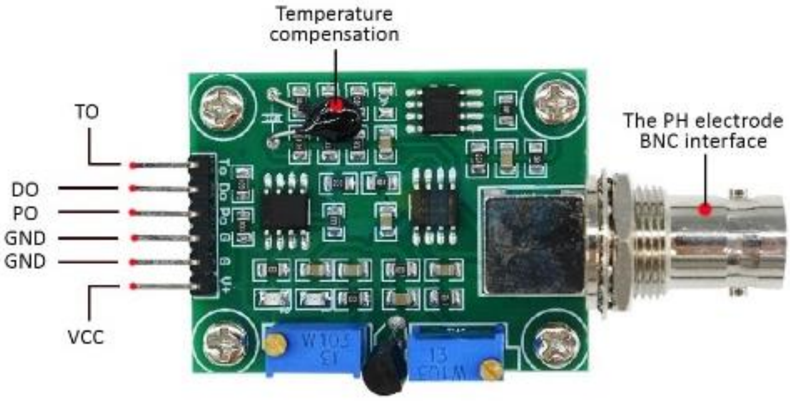

Figure 5. Modul pH sensor

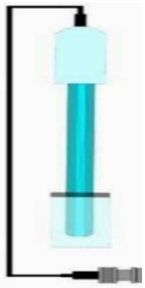

Figure 6. Probe pH sensor

2.5.3. NodeMCU Esp 8266

The NodeMCU uses the Lua programming language, which is easy to learn and use, is used to create the NodeMCU firmware [28]. The NodeMCU offers a complete collection of built-in modules that can be used to communicate with sensors, actuators, and other hardware. In addition, Arduino Software can be used to program the NodeMCU, making it easy to write and test. Various IoT initiatives, such as smart farming, industrial automation, and home automation, often use NodeMCU. NodeMCU has become a popular choice for amateur and professional developers due to its low cost and ease of use. It is a microcontroller board that already has a WiFi module that connects the microcontroller to a WiFi network. Depending on the commands programmed into the microcontroller, the microcontroller can also act as a client or a server [29]. Figure 7 is a display of the NodeMCU 8266 microcontroller. Based on the NodeMCU ESP8266 microcontroller datasheet, the allowable voltage source for the NodeMCU ESP8266 microcontroller is 3.3V to 5V, so the battery voltage will lower the DC-DC converter to 5V and then use the DC-DC converter down again to 3.3V for communication with the NodeMCU ESP8266 wireless module requires a voltage of 3.3V [30].

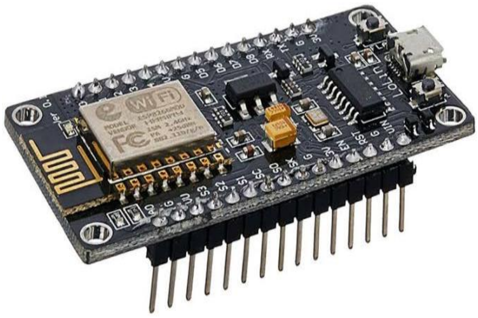

Figure 7. Mikrokontroller NodeMCU Esp8266

3. RESULTS AND DISCUSSION

The assembly of the components of this entire tool can be seen in Figure 8 with letter marks which will be explained as Table 2.

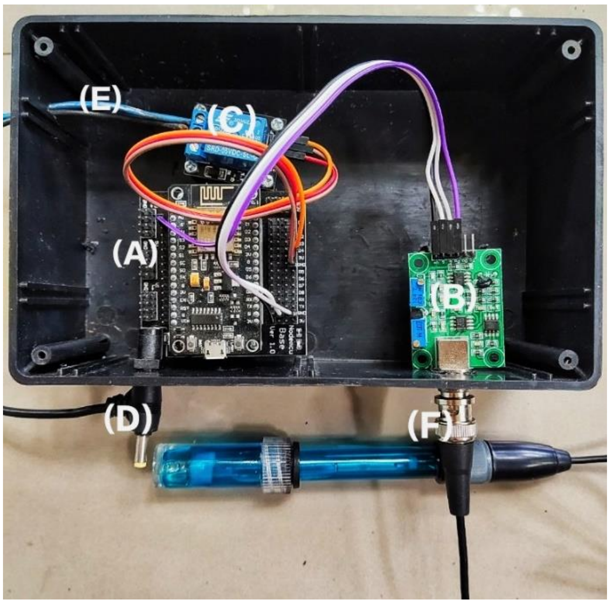

Figure 8. Result of tool realization

Table 2. Components of each tool

Component	Description
A	NodeMCU
B	pH Sensor 4502c Module
C	Relay 5V
D	Power Supply
E	220v voltage for motor
F	pH Sensor Probe

3.1. Testing Sensor pH 4502C

By testing the pH sensor, you can ensure that it consistently and accurately measures the pH of the solution. The pH sensor must be calibrated before use. This involves setting the sensor at two known calibration points. To calibrate the 4502c pH sensor on the blue Pot closest to the BNC connector is the offset potentiometer, which must be turned to get the correct offset. By connecting the BNC connector sensor in a short circuit. Adjust the offset potentiometer with a voltmeter until the PO reads 2.5V. testing in this study was carried out in a tilapia fish pond with an area of 20m x 25m. in the initial stage of testing the ph sensor must ensure that the ph sensor probe is on the water surface so that the reading can be done optimally. The reading process is carried out before and after the turbine aerator is active, so that data can be collected on what pH value is contained in the fish pond before the aerator is active and what pH value is read by the sensor after the aerator is active. To determine the level of accuracy of the pH value of water, a comparison is made with a pH meter so that the accuracy of the 4502c pH sensor reading can be calculated using the formula in (1) and (2).

$$\% \, Accuray \;=\; |1 \,-\, |\frac{Yn - Xn}{Xn}|| \times 100\,\% \tag{1}$$

$$\% \, Error = |\frac{Yn - Xn}{Xn}| \times 100\,\% \tag{2}$$

Where,
Yn is the measurement results with a pH meter and Xn is value read from pH sensor.

After all, the software and hardware design is complete, and the NodeMCU programming has been done, it can be seen directly using a cellphone with the blynk application what the pH content is in the fish pond water. Testing was carried out 10x with each time per 5 minutes. The results of the test. Table 3 can be seen the results of testing the pH sensor before the aerator is active, the average pH value of 6 indicates acid, from testing 1-10 the pH value read by the sensor is 6 and the comparison of measurements on the pH meter is 96% accurate.

Table 3. Testing the pH sensor before the aerator is active

Testing	Sensor pH 4502c	pH meter	% error	% accuracy
1	6	6.2	3%	97%
2	6	6.2	3%	97%
3	6	6.3	5%	95%
4	6	6.4	7%	93%
5	6	6.2	3%	97%
6	6	6.2	3%	97%
7	6	6.2	3%	97%
8	6	6.2	3%	97%
9	6	6.1	2%	98%
10	6	6.3	5%	95%
Several data			**10**	
Average accuracy			**96%**	

The second pH sensor test after the aerator is turned on is seen in Table 4. Test 1 shows the pH value at 6. Test 2 at 6, then test 3 after 10 minutes the pH value changes to 7 which means neutral. pH 7 is good enough in the water for fish farming. The level of accuracy of the comparison of sensors and pH meters is 96%.

Table 4. Testing the pH sensor after the aerator is active

Testing	Sensor pH 4502c	pH meter	% error	% accuracy
1	6	6.1	2%	98%
2	6	6.2	3%	97%
3	7	7.2	3%	97%
4	7	7.2	3%	97%
5	7	7.1	1%	99%
6	7	7.2	3%	97%
7	7	7.4	6%	94%
8	7	7.5	7%	93%
9	7	7.5	7%	93%
10	7	7.5	7%	93%
Several data			**10**	
Average accuracy			**96%**	

The results obtained from the sensor readings can be seen in the graph in Figure 9, the amount of pH value before the aerator is active is 6, the pH value is not good for fish for development. After the aerator is active, it can be seen in the graph in Figure 10. When the test is carried out 10 times with a time difference of 5 minutes, it can be seen that the pH value increases to 7-7.5 which indicates a neutral pH and very good water conditions for fish. It is very important to conduct accuracy testing to determine the error rate in sensor measurements. Therefore, the precision level of the 4502c pH sensor can be compared using a pH meter. The technique used is quantitative, and the accuracy of the 4502C pH sensor is 96% while the error value is 4% based on the findings from 10x trials and comparison of the pH sensor and pH meter.

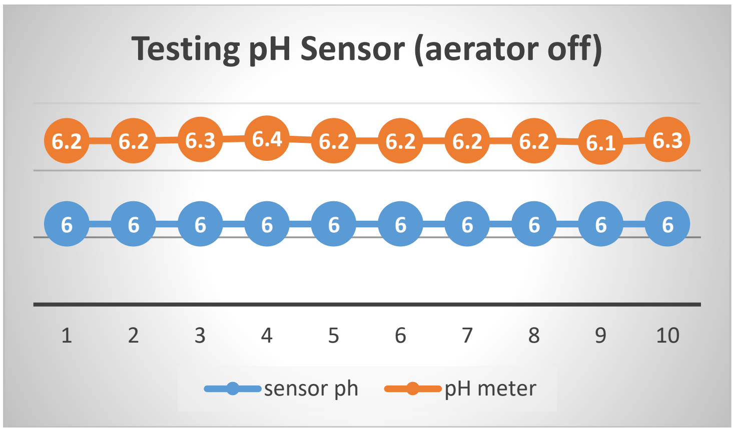

Figure 9. Graph of pH sensor readings (aerator off)

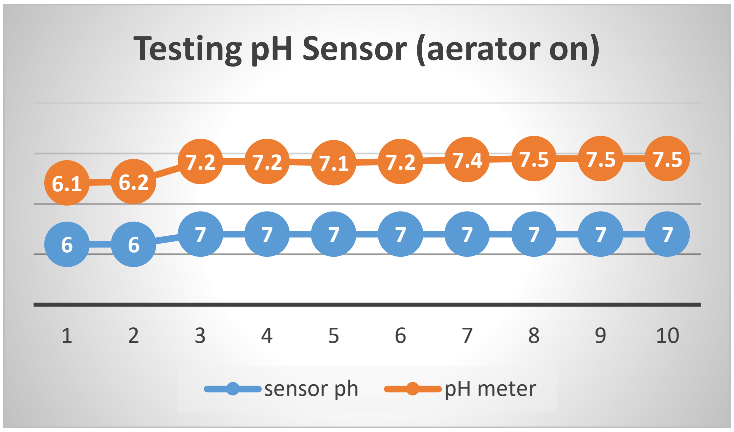

Figure 10. Graph of pH sensor readings (aerator on)

3.2. Testing Control Aerator

The turbine aerator is made using the internet of things system, for the display of the tool can be seen in Figure 11. By using a 1-phase motor and 2850 rpm. The rotation generated in the motor makes the oxygen above the water surface sucked down with the help of an impeller that has a shaft with a diameter of 19mm and a hole above as a circulation of air to be dissolved. The control process on the aerator is done using a handphone. An internet connection is required for the aerator control to run. To increase the amount of dissolved oxygen in the water, this aerator can work well.

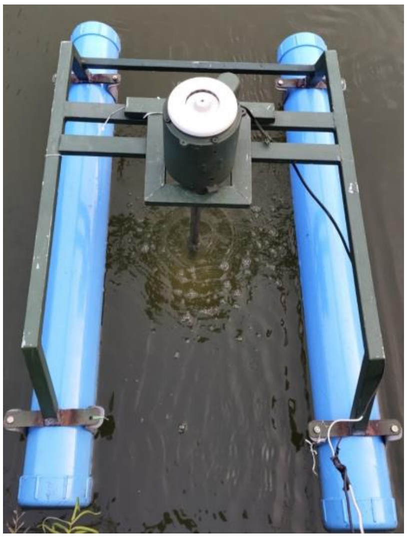

Figure 11. Aerator turbine

After programming and designing the tool, to run this aerator, the following steps can be taken:
1. Make sure your internet connection is active
2. Make sure the cable is connected to 220v electricity
3. Open the blynk IoT application on the cellphone
4. Click the aerator on the button to activate
5. Click the aerator off button to disable
6. The aerator is controlled and can monitor the pH of the water

3.3. Display Testing on Blynk

The Blynk display test is an experiment conducted on an Android phone that loads the Blynk application. A wifi internet connection is needed so that the monitoring process and also aerator control can be done. 4502 pH sensor readings and aerator control are displayed on the Blynk program. The aerator on the button activates the aerator to drive the motor. When the aerator is off to disable the aerator, the button functions as a digital switch control. The pH reading results will look as shown in Figure 12.

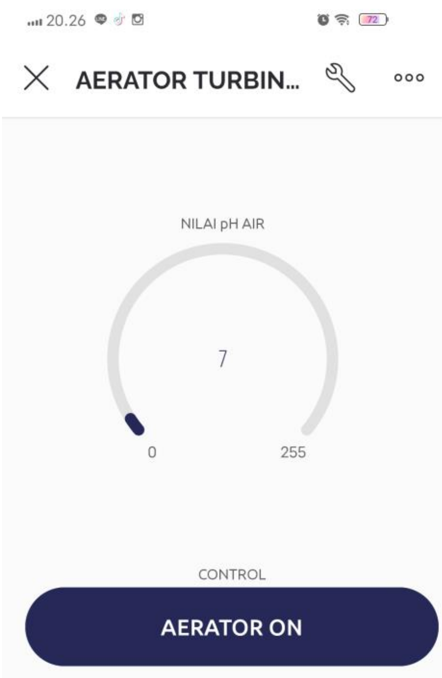

Figure 12. Display On Blynk

4. CONCLUSIONS

This research concludes that the turbine aerator can be controlled easily using a cellphone remotely which can be more effective in helping freshwater fish farmers to aerate the fish pond. To control and monitor the pH of water using the blynk application, but if there is no internet connection the tool cannot be active. In experiments and testing, this aeration tool is equipped with a pH sensor to determine the pH content in real-time. The results of sensor readings and tests carried out as many as 10x with each experiment with a time difference of 5 minutes the pH meter comparison figure shows an accuracy rate of 96% and an error rate of 4%. in the sensor reading test when the aerator is not active shows a value of 6 on the ph sensor display in the blynk application, and after the aerator is active the pH which was originally 6 becomes 7. This proves that the oxidation process that occurs by the aerator runs well so that water quality becomes better. The inclusion of a temperature sensor, automatic system, and LCD display can be added to this instrument in the future.

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