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IoT Platform for Monitoring Systems Water pH in the Freshwater Fish Cultivation Process

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ABSTRACT

This study describes the implementation of the Internet of Things using the MQTT protocol and mosquitto as a broker combined with a 2x16 LCD for a pH monitoring system in a freshwater fish farming system at BPBIAT Purwakarta, West Java, Indonesia. To obtain accurate data, the calibration process is carried out in several stages, including using buffer 6.8 and distilled water. The calibration results on the 6.8 buffered liquid sample mean that the data obtained are appropriate, while the aquades obtained a value of 7.73, this is due to the storage factor of the distilled water so that it can change the pH value. The final result of the research shows that the data that appears online on the Node-Red dashboard is the same as that which appears locally on the 2x16 LCD. This means the MQTT protocol is working fine. The data displayed on the Node-Red UI is sent periodically every 30 minutes. The consideration is that, during the experiments, the pH value of the water did not change significantly beyond the range of 6.5-8.5. This data illustrates that the pH quality of the water for freshwater fish farming at BPBIAT is ideal for use.

Keywords: Internet of Things, MQTT Protocol, Mosquitto Broker, Fish Farming,Water pH

Introduction

The problems that are often faced in the process of cultivating freshwater fish include failure of eggs to hatch caused by water quality that does not meet standards. Good water quality must meet the standard requirements for physical and chemical elements[1]. One of the chemical elements that supports the survival and growth of fish is the pH level of the water[2].

Management of water quality in fish farming is regulated in SNI 7550 of 2009. In this regulation the permitted pH range is between 6.5-8.5[3]. Because there are quite a lot of problems that often arise in the process of cultivating freshwater fish, this has become very interesting for previous researchers through various research methods.[4]–[7]. In this regard, there is research that develops a freshwater quality monitoring system by implementing a prototype in an aquarium

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using an arduino controller. [8]. Apart from that, there are also those who use the 4502C pH sensor module and a web server as monitoring media [9]. Other researchers also use LabView as a monitoring device that is integrated with a microcontroller [10].

On the other hand, Internet of Things (IoT) [11], [12] has become part of various sectors including the agricultural industry [13] including in the fisheries sector [14]. So from previous research, there is still a research gap that allows new research to be opened on this topic, including the creation of an IoT-based monitoring system that uses the MQTT protocol[15] and is equipped with a local monitoring system using an LCD. Therefore, this research aims to fill this research gap. The research question in this study is how to present accurate data visualization, both online and offline but still easy to use by officers in the field.

Methods
The method in this research is as follows: The initial stage is to determine the fish variant that is the object of research, namely the process of cultivating goldfish and tilapia eggs. Next, determine the research location, namely the Freshwater Fish Seed Development Center (BPBIAT) Purwakarta, West Java, Indonesia. Next, determine the ideal pH data for these two fish, which is between 6.5-8.5 and calibrate the pH sensor with several tools and calibration materials. Then choose a controller, namely NodeMcu ESP8266 and create a program with instructions to publish data to http://test.mosquitto.org and also send data to the 2x16 LCD via the I2C module. The next stage is to install the MQTT protocol on Node-red on a localhost PC/Laptop with the address: http://localhost:1880, then send data subscription instructions to http://test.mosquitto.org. After that, display the data on the Node-Red dashboard with the address: http://localhost:1880:/ui and take the test results data and process it. The final stage is to draw conclusions from the research results and discuss the research presentation.

In the process of determining the monitoring system, this research uses the MQTT protocol which is installed on Node-Red [16]. This protocol is a simple and light protocol with a publish and subscribe architecture and is capable of handling thousands of clients with just one server [17]. Besides data that can be monitored via the Node-Red Dashboard, data can also be monitored locally via the LCD which is connected via the I2C module to the ESP8266 NodeMCU[18]. In full, the block diagram of this system can be seen in Figure 1.

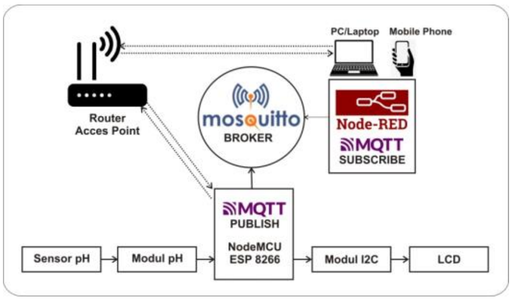


Figure 1. Monitoring System Block Diagram

Results and Discussions
To obtain accurate data, the sensor calibration process is very important. This process is carried out in several stages, including using buffer 6.8 and distilled water. Testing on a 6.8 buffer liquid sample, the sensor can measure according to the buffer's standard pH value, which means the sensor accuracy is quite good. Meanwhile, the value obtained for distilled water was 7.73, which could be caused by the storage factor of the distilled water liquid so that it could change the pH value (Table 1).

Table 1. Data from pH meter sensor calibration results

No	Sample	pH Standard Test Value	Average pH Value of Test Equipment
1	Buffer 6.8	6.8	6.82
2	Aquades	7	7.73

The results of the sensor calibration tests that have been carried out can be seen in Figures 2a and 2b. Figure 3 is a reference scale for pH values used in this research.

a b

Figure 2a. pH Calibration in Buffer Solutions 6.8 **2b.** pH calibration in Aquades

Figure 3. pH reference value scale

Next step, the sensor was also tested with several liquid samples such as NaOH, apple cider vinegar, and $H_2C_2O_4$ (oxalic acid). The test results can be seen in table 2 below.

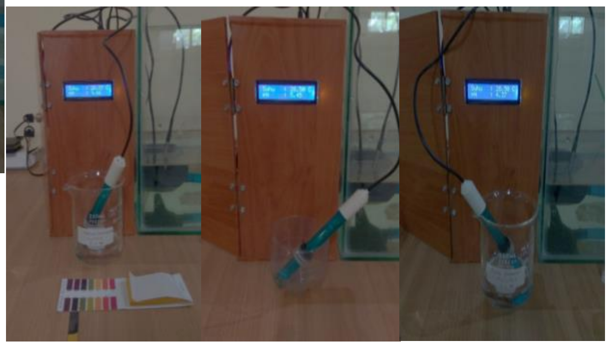
Table 2. Data from pH Meter Sensor Detection Test Results

No	Solution Sample	pH Value with Litmus	Average Value pH	Sensor Error (%)
1	NaOH	10	9.66	0.03
2	Apel Cider	5	5.45	0.09
3	H2C2O4	2	4.37	1.18
Error average				0.51

Based on the data in Table 2, it can be seen that there is a difference between the data from measurements using litmus paper and the pH meter sensor. To calculate the difference in error on the pH sensor, the following formula is used:

$$Error = \frac{pH\ margin}{pH\ data\ in\ litmus\ paper} \times 100$$

Because there is a difference in value between the two pH indicators, to get an accurate value it is necessary to calibrate the pH meter sensor using a calibration buffer that has the expected value range, namely pH 4 and pH 7, compared to using pH 7 and pH 10. Figure 4a , b and c are the results of detection calibration from the pH meter sensor.



a b c

Figure 4a. pH Calibration in solutions of NaOH **4b**. pH Calibration in Apple Cider Vinegar Solution **4c.** pH Calibration in Solutions of $H_2C_2O_4$

In previous research, the pH testing process used several samples which were used as reference measurement values, namely pH Buffer Powder 4.00, pH Buffer Powder 6.89, pH Buffer Powder 9.18, vinegar water, baking soda, and soapy water [10]. See figure 5.

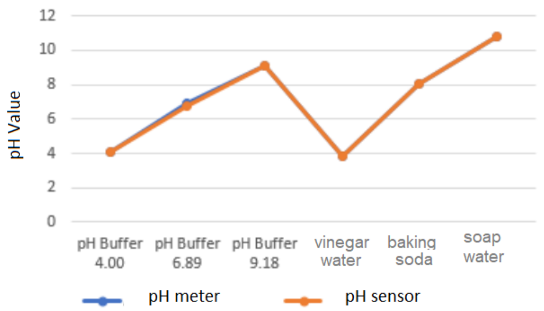


Figure 5. Calibration of pH Sensor Values vs Standard pH Meter Measuring Instruments

From this sample the error obtained was 0.05. When compared with the error in this study there is a gap of 0.45. This difference in tolerance is caused by different calibration media, namely litmus paper and buffer powder. However, even though there are differences, the error tolerance limit between previous research and this research remains within the allowable accuracy limit in reading pH values.

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Implementation of pH Meter Sensor Reading on NodeMCU ESP8266

The pH sensor that has been calibrated is then implemented in the water that will be used for the fish cultivation process. The pH sensor is positioned hanging and the core of the sensor (glass bulb) is immersed in the water surface. Data from pH sensor readings can be seen in table 3.

Table 3. Data from pH Sensor Testing Results on Aquarium Water

Test number	ADC Value	Voltage (V)	pH	Water pH
1	434	2.12	7.42	Normal
2	438	2.14	7.49	Normal
3	432	2.11	7.38	Normal
4	430	2.10	7.35	Normal
5	417	2.03	7.11	Normal
6	426	2.08	7.28	Normal
7	422	2.06	7.21	Normal
8	428	2.09	7.32	Normal
9	422	2.06	7.21	Normal
pH average			7.30	Normal

From table 3, the pH sensor reading values can be visualized through the graph in figure 6.

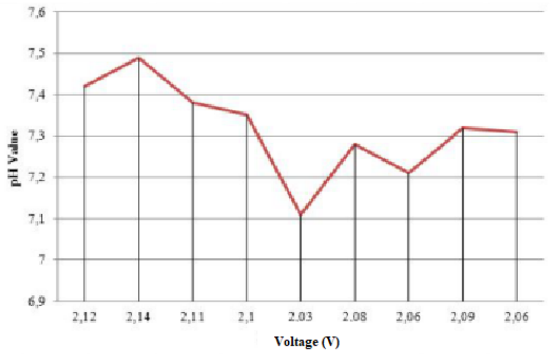
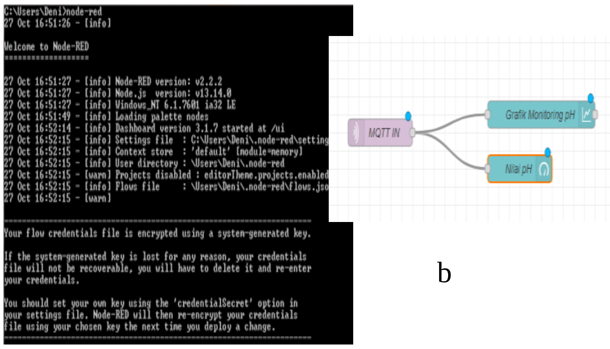


Figure 6. Data Graph of Implementation Results of pH Meter Sensor Readings (Voltage vs pH Value)

From this graph it can be explained that the pH value is in the range 7.1-7.49, meaning that this value shows that the water used for the freshwater fish cultivation process at the research location has a good and safe pH level because it corresponds to the ideal pH range, namely between 6.5-8.5 .

Data visualization on Node-Red Dashboard

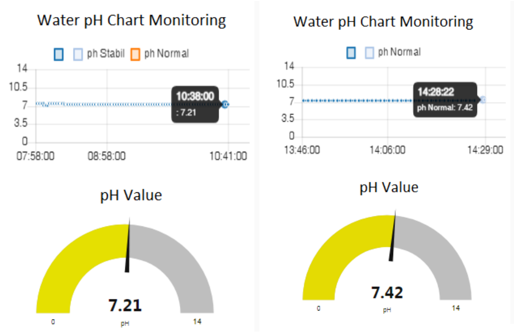
So that data can be monitored online, Node-Red, which has been installed, must be activated first as shown in Figure 7a. Next, create an MQTT subscribe flow (7b) to get pH value data from the sensor connected to the ESP8266 NodeMCU in publish mode.



a b

Figure 7a. Node-Red Activation **7b.** MQTT Protocol Flow on Node-Red Dashboard.

The sensor data results can be seen in Figures 8a and 8b as follows:



a b

Figure 8a. pH value data in the morning **8b.** pH value data in the afternoon

The test results show that the data that appears online on the Node-Red dashboard is the same as that that appears locally on the 2x16 LCD. This means that the MQTT protocol is working properly. The data displayed on the Node-Red UI is sent periodically every 30 minutes. The consideration is that, during the tests carried out, the pH value of the water did not change significantly beyond the limit range of 6.5-8.5.

Conclusions

The MQTT protocol implemented on the Node-Red and NodeMCU ESP8266 can work well and corresponds to the data displayed on the 2x16 LCD. With a publish and subscribe architectural pattern, this protocol is able to show good performance in processing sending and receiving data with the help of the mosquitto broker. To obtain an accurate pH value, the sensor calibration process is very important. This process is carried out in several stages, including using buffer 6.8 and distilled water. The final test results show that the pH value is in the range 7.1-7.49, meaning that this value shows that the water used for the freshwater fish cultivation process at the research location has a good and safe pH level because it matches the ideal pH range, namely between 6.5-8.5.

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Author Contributions

Conceptualization, investigation and software, Deni Kurnia; methodology and formal analysis, Slamet Riyadi; validation, resources, writing—review and editing, Adolf Asih Suprianto ; data curation and writing—original draft preparation, Olivia Rahmadani; visualization and supervision, Deshinta Arrova Dewi; All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

This research is independent research that is not funded by any agency. There are had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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