The IoT-based pH sensor's performance in detecting the acidity level of catfish pond water in the Cadek area of Aceh Besar Regency.

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Abstract

In catfish cultivation, fish growth conditions will be optimal if they are in the pH value range of 6-9. This water quality problem becomes a major problem for catfish farmers in the Cadek area of Aceh Besar district, when the water pH is not normal. The developing internet of things (IoT) technology can really help or make it easier for farmers to control water pH. The aim of this research is to design a water pH monitoring tool using IoT-based tools. This research model applies the 4D model, namely define, design, develop, disseminate. some of the equipment used is NodeMCU, pH sensor, water pump relay, Blink application and pHmeter. The results of the feasibility of this tool carried out by 2 expert validators in the field of electrical engineering were obtained in the very feasible category. The next stage was to test the device 10 times using the Blynk application and a pHmeter. In the Blynk application, the average pH value read is 5.67. Meanwhile, when measured with a pHmeter, the average pH value read was 5.92. This designed tool can provide pH values regardless of position without having to be close to the catfish pond, so that farmers can check the pH of the pond water from a distance. It can be concluded that good accuracy of the fish pond acidity test equipment has been obtained and is a positive step in ensuring the health and survival of fish as well as operational efficiency.

Keywords*: Internet of thing (IoT), pond acidity levels, catfish*

Abstrak

Dalam budidaya ikan lele kondisi pertumbuhan ikan akan optimal jika berada dalam rentang nilai pH 6-9. Masalah kualitas air ini menjadi utama bagi pembudidaya ikan lele di daerah Cadek kabupaten Aceh Besar, ketika pH air tidak normal. Melalui teknologi internet of thing (IoT) yang berkembang dapat sangat membantu atau memudahkan peternak dalam mengontrol pH air. Tujuan dari penelitian ini untuk merancang alat monitoring pH air menggunakan alat berbasis IoT. Model penelitian ini menerapkan model 4D yaitu define, design, develop, disseminate. Beberapa peralatan yang digunakan berupa NodeMCU, sensor pH, Relay, pompa air, aplikasi Blink dan pH meter. Hasil dari Kelayakan alat ini dilakukan oleh 2 ahli validator di bidang elektro diperoleh dengan kategori sangat layak. Tahap selanjutnya dilakukan uji coba alat sebanyak 10 kali pengontrolan menggunakan aplikasi Blynk dan alat pHmeter. Pada aplikasi blynk nilai pH rata-rata yang terbaca yakni 5,67. Sedangkan pada pengukuran dengan pHmeter nilai pH rata rata yang terbaca adalah 5,92. Melalui alat yang dirancang ini sudah dapat memberikan nilai pH walau posisi tanpa harus berdekatan dengan kolam ikan lele, sehingga peternak dapat mengecek pH air kolam dari jarak jauh. Dapat disimpulkan akurasi yang baik dari alat uji keasaman kolam ikan telah diperoleh dan menjadi langkah positif dalam memastikan kesehatan dan kelangsungan hidup ikan serta efisiensi operasional.

Kata Kunci*: Internet of thing (IoT), kadar keasaam air kolam ikan, ikan lele*

Introduction

The integration of Internet of Things (IoT) and sensors has indeed revolutionized the electronic landscape by enabling interconnected systems that gather, process, and exchange data in real-time [1], [2]. This synergy between IoT and sensors has opened up a myriad of possibilities across various industries and applications [1], [2], [3], [4]. IoT allows electronic devices to be interconnected, creating a network where data can flow seamlessly between devices and systems. Sensors play a crucial role in this network by gathering data from the physical world and transmitting it to IoT platforms for analysis and action[5]. In the electronic world, IoT and sensors frequently collaborate to create closed systems that can provide useful information or analyze the surrounding environment.

Sensitive sensors within the environment can gather data for analysis to determine more accurate decision-making when handling daily supplies [2], [5]. Sensors collect data on various physical parameters such as temperature, humidity, pH, pressure and air quality sensors [4]. This data is then processed by IoT systems to derive meaningful insights, make informed decisions, and trigger automated actions. the combination of IoT and sensors has transformed the electronic landscape by creating interconnected systems that gather, analyze, and act on data in real-time, driving efficiency, innovation, and new opportunities across various domains [2], [5].

One industry that could be created to enhance community wellbeing is fish aquaculture [3], [6], [7], [8]. Indonesians frequently raise a variety of fish, including grouper, tilapia, mackerel, shrimp, and catfish. The ideal pH range for fish growth in catfish farming is 6 to 9, and the ideal temperature range is 26 to 30°C [9]. Within these ranges, catfish can thrive, feed, and grow efficiently. Any deviations from these ranges can stress the fish and hinder their growth. Maintaining stable pH levels and water temperature is crucial in catfish farming to ensure optimal growth and health of the fish [3], [7], [8], [9]. Fluctuations in pH and temperature can indeed lead to poor water quality and even mortality among young fish. As a result, consistent observation is required to keep the pH and water temperature stable. Sudden changes in pH may indicate water contamination, excessive organic matter decomposition, or inadequate aeration, all of which can negatively impact fish health.

Generally, catfish live normally in an environment that has a dissolved oxygen content of 4 mg/l [8]. The oxygen content often changes suddenly when organic matter decomposes which affects the pH of the pool water. When the acidity or pH of a fish pond is less than 5, it has a very bad influence on catfish, causing mucus to clot in the gills. whereas when the pH is 9 and above it will cause the catfish's appetite to decrease. This observation can be obtained by employing sensors or by removing water samples from cultivation ponds and examining them in a lab setting. The use of pH sensors allows farmers to detect these changes quickly so that corrective action can be taken immediately. Through continuous monitoring of water pH, farmers can optimize cultivation conditions to improve growth, health and productivity of catfish [7], [10].

The physical state of water bodies in catfish farming can change rapidly, especially in the presence of contaminants. These contaminants can originate from both internal (such as dead fish) and external (such as trash and food waste) sources and can have detrimental effects on water quality and fish health [3]. So, the purpose of this study is to evaluate how well IoT-based pH sensors measure the acidity of water in catfish aquaculture ponds.

Methodology

This research took the location of the catfish pond in the Cadek area, Baitussalam sub-district, Aceh Besar. This study was classified as a type of research and development. This research uses a 4D model consisting of define, design, develop and disseminate [11], [12]. Furthermore, the system for detecting acidity levels in catfish ponds uses the following tools:

1. NodeMCU: This serves as the main microcontroller board based on the ESP8266 SoC. It provides the processing power and connectivity for the IoT system. [3], [8], [13]
2. pH Sensor: The pH sensor measures the concentration of hydrogen ions in a solution. Regular calibration is necessary to ensure accuracy in pH measurements [8].
3. Serial Monitor: The pH sensor calibration interface program is loaded via the serial monitor, allowing users to calibrate the sensor. Calibration results are stored in EEPROM for future use.
4. Jumper Cables: These cables are used to connect components such as the pH sensor, relays, and water pump to the NodeMCU microcontroller.
5. Relays: Relays act as current-controlled switches, enabling the microcontroller to control high-power loads or devices with different electrical systems. They serve as intermediaries between the electronic control system and the load s.

6. Water Pump: The water pump is used to move fluid from one place to another using pipe media. It may be controlled by the NodeMCU via a relay, allowing for remote activation and deactivation.
7. Blynk IoT Platform: Blynk provides an IoT platform that allows users to create custom interfaces in mobile applications. It enables remote control and monitoring of hardware connected to the NodeMCU via the internet network.

The schematic of the design of an IoT-based pH sensor to detect the acidity level of catfish pond water was showed in Figure 1.

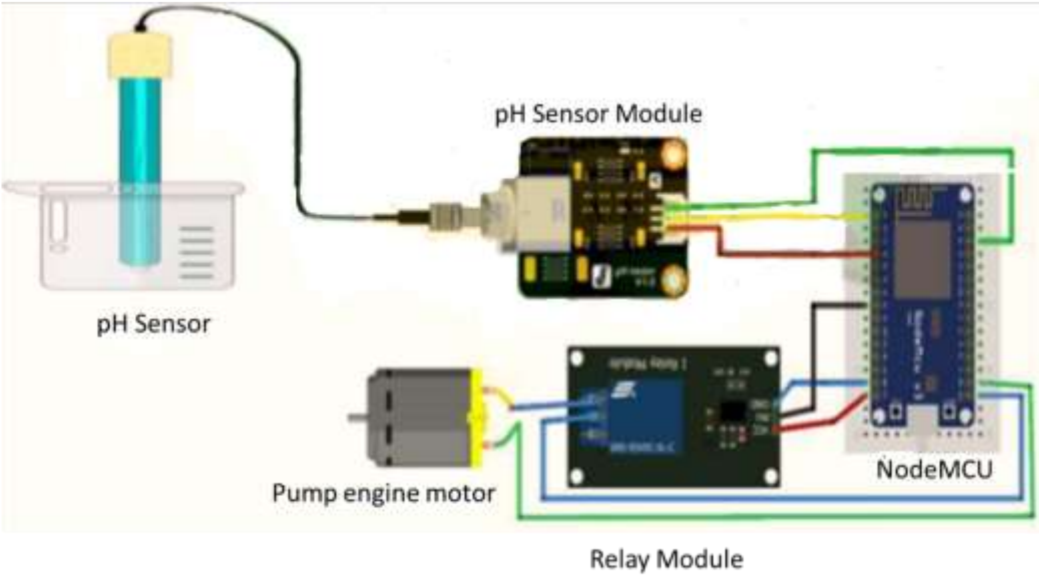

Figure 1. Schematic of the design of an IoT-based pH sensor

This system was designed using IoT technology, which enables users to remotely monitor and control water pumps based on pH measurements obtained from sensors. The NodeMCU is used as the central hub for data processing and communication, and Blynk provides an interface for users to interact with the system via a mobile application.

The next step was to validate the IoT-enabled pH sensor by a team of validators. In assessing the feasibility of the product, 2 experts have been selected who have abilities in the field of electronics. Several aspects assessed by validator experts for IoT-based pH sensors include:

a. Functionality: Ensures the tool functions correctly in measuring water pH and sending accurate pH data.
b. Accuracy: Check the accuracy of the water pH measurement results by the tool.
c. Performance: Test tool performance in various situations and conditions in different environments.
d. Connectivity: Ensure the device can connect to the network IoT and can transmit data.
e. Security: Check for potential security vulnerabilities and evaluate the security measures that have been implemented.
f. Ease of Use: Assesses the tool's ability to be easy to use and operate by the user.
g. Construction Quality: Assess the physical quality of the tool and how the tool works resistant to environmental conditions that may occur in catfish ponds.

To assess the performance of an IoT-based pH sensor for monitoring the acidity level of catfish pond water using a Likert scale. Each statement will be rated on a Likert scale, such as (5) Very Feasible, (4) Feasible, (3) Neutral, (2) Inappropriate and (1) Very Inappropriate [14]. Gather the completed assessment sheets from all experts. Each expert's responses will provide a score for each statement. Calculation of product feasibility value using percentages shown in equation 1.

$$\text{Feasibility Percentage} = \frac{Maximum\ Score}{Total\ \ Score}\ x\ 100\ \% \quad (1)$$

And the categories of expert assessment results are based on the following percentage levels as shown as Table 1.

Table 1. Product eligibility criteria by expert assessment [14]

Categories	Percentage levels (%)
Very Feasible	81-100
Feasible	61-80
Neutral	41-60
Inappropriate	21-40
Very Inappropriate	0-20

At the testing stage, the revised IoT-based pH sensor system is implemented to monitor the pH levels of catfish pond water.

Result and Discussion

The following was documentation of an IoT-based pH sensor device for detecting acidity levels in catfish ponds as shown in Figure 2.

Figure 2 IoT-based pH sensor device

Figure 3 below is a form of visualization and data collection for aspects assessed by experts regarding IoT-based pH sensor products. Based on Figure 3, it can be seen that the general appearance and practicality assessed by experts of the IoT-based pH sensor are rated in the very feasible category with average values of 89.95% and 90%, respectively. Meanwhile, for the product quality aspect, it gets score an average value of 80% in the feasible category.

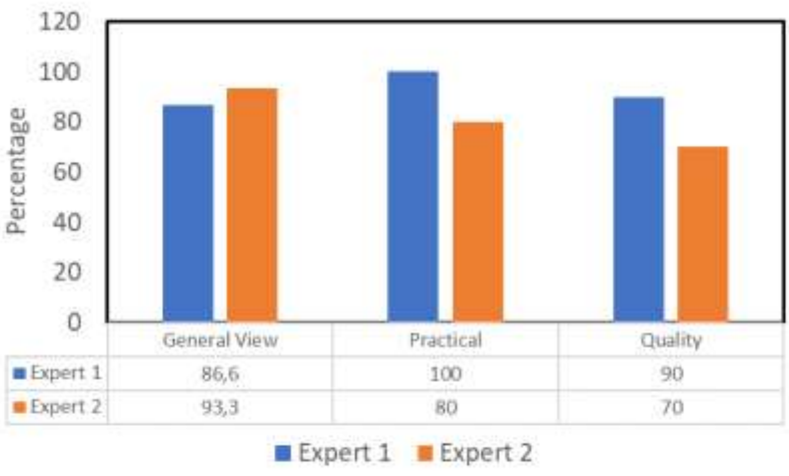

Figure 3. Charts and data collection from Product validation by an Expert assessment

The IoT-based pH sensor product feasibility data shown in the graph and table above is the final value after product improvements according to suggestions from the expert team. Suggestions for improvements from the expert team such as adding switches and attaching circuit images to the product.

Table 2 Data from measuring the acidity levels of catfish ponds using an IoT-based pH sensor and pH meter

Testing	IoT-based pH sensor		pH meter	
	pH value	Acidity level	pH Value	Acidity level
1	3,87	Acid	4,03	Acid
2	5	Acid	5,09	Acid
3	7,02	Normal	7,13	Normal
4	6,73	Normal	6,89	Normal
5	6,56	Normal	6,73	Normal
6	6,01	Normal	6,09	Normal
7	6	Normal	6,04	Normal
8	3,95	Acid	4,25	Acid
9	5,14	Acid	5,32	Acid
10	7,39	Normal	7,56	Normal

Based on Table 2, it can be observed that at the beginning of the measurements (tests 1 and 2) for two different times on the same test day, it was found that the acidity level value of the catfish pond was at the acid level with a pH value below 6. This value was shown well through the IoT-based pH sensor or those using a pH meter. Based on the numerical values shown by the tool, the researchers immediately replaced the catfish pond water with clean water and carried out the third test and found the pH of the pond water to be at a normal level. The re-testing process was carried out again on the fish pond water for the next 4 days (test 4-7) and it was found that the pond acidity level was within normal levels with a value range of 6-7. However, when measurements were carried out again the following day, it was found that the acidity level of the pool water was already at an acidic level with a pH value below 6 (Test 8-9). With the notification provided by the blink application to the cellphone about the pH value of the pool water, the researchers replaced the water again with clean water The process of changing pool water takes 1-2 hours. In the 10th test, after the pool water was replaced, the pH value returned to normal levels.

Of the 10 tests that have been carried out over 6 days, good performance has been demonstrated by the IoT-based pH sensor, where the value read in the blink application is almost the same as measuring acidity levels directly with a pH Meter. Through monitoring and control using the Blynk application, pH values and levels can be visualized in real-time. If the pH level deviates from the normal level, there will be an instruction to turn on the water pump which is controlled via a relay to add water to adjust the pH value.

The testing phase shows the effectiveness of the IoT-based pH sensor system in monitoring and maintaining the acidity level of catfish pond water. The system's accuracy, reliability and user-friendly interface provide significant benefits to catfish farmers, ensuring optimal conditions for fish growth and health. IoT-based pH sensor monitoring tools depend on connections internet, if there is a network disruption then the incoming notification on the Blynk application will also be late. This means that control of the fish pond water will be disturbed and there is a risk of catfish death.

Conclusion

Research on the effectiveness of IoT-based pH sensors in measuring the acidity of catfish pond water has been successfully carried out. With NodeMCU as a microcontroller board combined with a pH sensor, it has been able to show good performance in measuring the acidity level of pool water. The measurement results with the IoT system created show similar values which are not much different when compared to the pH meter. Apart from that, the IoT system created has received very suitable criteria from the expert assessment team for 2 of the 3 aspects assessed. So, it can be concluded that the ease of reading values in real time on the IoT system created can be a solution in cultivating catfish and will overcome the problem of pond water which has the potential to easily become acidic. Further improvements could focus on increasing sensor durability, extending battery life, and integrating additional environmental sensors for comprehensive water quality monitoring.

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