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Internet of Things (IoT) and Arduino IDE as a Smart Water Quality Control for Monitoring in Catfish Ponds

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Abstract

This research aims to develop a monitoring and control system for catfish pond water quality based on the Internet of Things (IoT). This system uses an ESP32 microcontroller Arduino Integrated Development Environment (IDE) connected to a SEN0131 pH sensor, DS18B20 temperature sensor, and HC-SR04 ultrasonic sensor to monitor water quality parameters such as pH, temperature, and water level. Data obtained from these sensors is stored in a real-time database that can be accessed remotely via the Blynk application. This system is also equipped with a water pump and solenoid valve that automatically controls water filling and discharge based on detected water quality parameters. The test results show that the system has an average accuracy of 99.45% and high precision with an average relative standard deviation of 0.01% in detecting water quality parameters. System operation was carried out for 27 days. The system can run continuously or non-stop. data is input in real-time to blynk, so it can be monitored and controlled from anywhere.

Keywords: arduino integrated development environment (ide); automated water control; catfish pond manegement; internet of things; real-time water monitoring ; water quality monitoring

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INTRODUCTION

Fish farming is an effort that can be made by the community in order to provide animal protein sources, in addition to the cultivation business indirectly helps to succeed the development program in the fisheries sector (Saparinto, 2013). Catfish cultivation can simply utilize a tarpaulin pond as its environment (Ighalo et al., 2021). Tarpaulin ponds are easy to make and propagate on a land that is not too large, and does not require too large commercial capital to facilitate the fish harvesting process (Sanjaya&Badarina, 2021).

Pond control and monitoring in aquaculture is very important for the good growth and development of catfish (Pasika & Gandla, 2020). Good market control, catfish rearing technology and the right strategy in terms of pond preparation, seed selection, water replenishment, feed management, water quality management, harvest management, greatly affect the profits of fish farmers (Nugroho, 2007). To achieve high yields, cultivation is carried out intensively. Intensive catfish cultivation is the spread of a high number of fish seeds and the use of a fairly high amount of feed. This will have an impact on increasing waste from leftover feed, feces and metabolites of catfish and if disposed of outside it will pollute the environment, so it can pollute the surrounding aquaculture environment. Technology is needed that can help control and monitor water quality (Jan et al., 2021).

Technology is developing rapidly in various fields, one of which is in the field of fisheries. Technologies needed in fisheries such as automation technology that can make it easier to control the water conditions in the aquaculture pond, one of which is such as a pH control system and water turbidity as a way to increase fish growth (Lakshmikantha et al., 2021). The state of pond water quality will play a role in the condition and performance of the cultivated catfish. Fisheries aquaculture production can be affected by seed quality, feed quality and water quality (Sugianti & Hafiludin, 2022).

Based on the problems experienced by tarpaulin pond media catfish farmers who experience difficulties in regulating and determining water quality. And the way to measure pH and turbidity still uses traditional methods and improvised equipment. Much research has been carried out regarding water quality and quantity monitoring instrumentation, such as research conducted by Pratama et al.,(2022), namely on water quality monitoring tools using water pH sensors and Arduino UNO. The study only measured the acid/alkaline level of water. Research conducted by Dewantoro & Ulum, (2021) is about a water quality monitoring system in catfish cultivation based on the Internet of Things (IoT). This research has used IoT technology, but only measured the acid/alkaline level of water and water temperature and only carried out monitoring for a short time. The monitoring system created is still not flexible and indicators need to be added.

In recent years, several aspects of industry have started to use IoT as a tool in control systems. The Internet of Things (IoT) plays a crucial role in environmental monitoring and sustainability. In Environmental Monitoring, IoT enables consistent data collection from physical environments using sensors and connected devices (Chafa et al., 2022). These devices can detect temperature, moisture, water levels, leaks, and other properties. The data is then processed using edge computing technology and sent to the cloud for analysis (Zulkifli et al., 2022). On the other hand, across various industries use IoT to optimize operations and make sustainable decisions. By monitoring processes and detecting abnormalities, IoT helps reduce harmful pollutants and protect air, soil, and water (Mutri et al., 2024).

Based on previous research, it is necessary to create water quality parameters. A database system that can be accessed remotely which is useful for monitoring and analyzing the quantity and quality of catfish pond water and is able to control water replacement if necessary. In this research, a system for monitoring and controlling physical water parameters such as water pH and water temperature will be designed and created using the Internet of Things (IoT) application using an ESP32 microcontroller Arduino Integrated Development Environment (IDE). The monitoring and control system is built using two physical water quality parameters whose data is stored in a real-time database system that can be accessed remotely.

METHOD

The research method used is Research and Development. Research and Development is a research method used to produce certain products, and test the effectiveness of these products (Sugiyono, 2010). Development research is a research approach to produce a new product or improve an existing product (Djamaludin et al., 2022). The development model used is the waterfall development model. **Figure 1** shows the stages of the waterfall development model.

Figure 1. Stages of the waterfall development model

This system design is a description of the system that will be designed. This block diagram can also explain the working mechanism of an Internet of Things-based water quality monitoring and control system. Monitoring and control system with microcontrollers and sensors to detect water physical parameters. The system is placed in a box as a safety measure. Inside the box there are the electronics used and there are also sensors that are directly dipped into the catfish pond. The system program was created using the Arduino Integrated Development Environment (IDE). The system takes information on water quality parameters detected by sensors which are processed by the MCU Node, then the data will be sent to Blynk and action will occur on the automatic faucet and water pump if the water concentration matches the water quality parameters for raising catfish (Hong et al., 2021; Okoli & Kabaso, 2024). **Figure 2** is a design for an IoT-based system for monitoring and controlling water quality for catfish ponds.

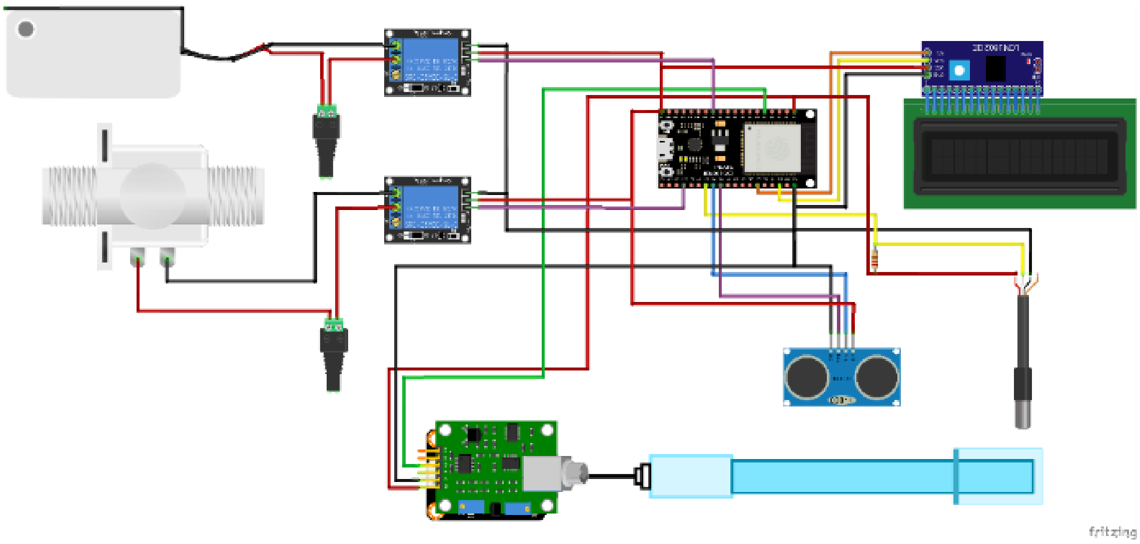

Figure 2. System electronic circuit

The system testing carried out was testing the sensors used and the entire system for monitoring and controlling the water quality of the catfish rearing pond based on IoT (Internet of Things). Sensor testing is carried out to determine the detection capability of each sensor. The next process is real-time operation and maintenance. This process serves to see whether the performance of the water quality monitoring and control system is functioning properly. This process takes place in catfish pond water that has been cultivated for one week.

After the data is collected, then analyze the data that has been collected. Data analysis is carried out by first processing the data obtained. Analysis of target data to see the performance of the water pump control device based on the water quality designed as an evaluation step. The data that will be analyzed is data on the characteristics of the water pump control device based on water quality, including error (1), accuracy (2) and precision (5).

$$\epsilon = \left|\frac{e}{\tilde{x}}\right| \times 100\ \% \tag{1}$$

$$Accuracy = 100\ \% - Error \tag{2}$$

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(xi-\tilde{x})^2}{n-1}} \tag{3}$$

$$RSD = \left(\frac{SD}{\tilde{x}}\right) \times 100\ \% \tag{4}$$

$$Precision = 100\ \% - RSD \tag{5}$$

Equation (1) is an equation for determining relative error. Equation (2) is an equation to determine the accuracy value. Equation (3) is an equation for determining standard deviation. Equation (4) is an equation to determine the relative standard deviation. and equation (5) is the equation for determining the precision value. Equation (1) is an equation for determining relative error. Equation (2) is an equation to determine the accuracy value. Equation (3) is an equation for determining standard deviation. Equation (4) is an equation to determine the relative standard deviation. and equation (5) is the equation for determining the precision value.

RESULTS AND DISCUSSION

In the system circuit there is a pH sensor, temperature sensor and ultrasonic sensor as input. Then the detection of these sensors will be processed on the ESP32 MCU Node to move the relay and connect to the blynk. The process for making electrical hardware for a catfish pond water quality monitoring and control system is as follows.

a. Design of system circuit schematics using the fritzing application. This design aims to simplify the process of assembling electrical hardware. The circuit and circuit schematic of the components used can be seen in **Figure 2**.
b. Install all components on the panel box by connecting all components to the Node MCU pins. Installation of components on the panel box can be seen in **Figure 3.**

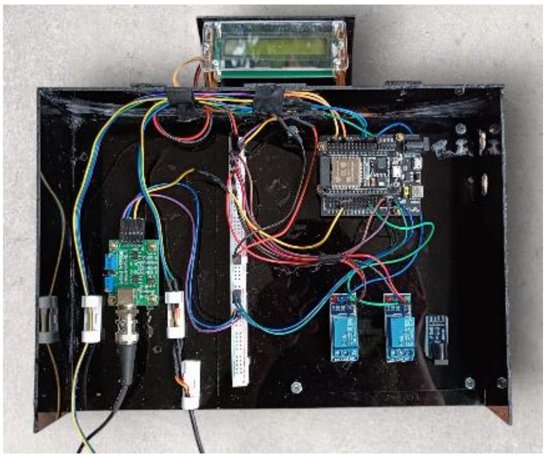

Figure 3. Water quality monitoring and control system circuit

System design is carried out in several steps, namely as follows. The catfish pond media will be made from tarpaulin with a square size of 100 cm and a height of 80 cm. In the catfish pond there are four sensors, namely the pH sensor, temperature sensor, min water level sensor and max water level sensor. Filling the pool water is done using a water pump connected to a water source/well. Filling water into the pool is carried out if the water has reached the min pool height sensor and the pump will stop when the sensor has reached the max height of the reservoir water. The sensors used in the process of monitoring and controlling water quality are the SEN0131 pH sensor as the pH parameter, the DS18B20 sensor as the temperature parameter and the ultrasonic sensor as the water level parameter. **Figure 4** is the installation of non-electronic hardware

Figure 4. Non-electronic hardware

The next stage is testing the sensors and accuators of the system. System testing aims to measure the system's ability to detect air quality parameters and control air based on air pH. Table 1 is data from testing the sensors and actuators of the system. From the test results data it can be interpreted that the system can detect water quality parameters with great accuracy and precision with small errors.

Table 1. System test result data

No	Sensors and Actuators	Error (%)	Accuracy (%)	Relative Standar Deviation (%)
1	pH sensor	±0.53%	99.47%	0.01%
2	Temperature sensor	±0.24%	99.76%	0.005%
3	Distance sensor	±0.13%	99.87%	0.001%
4	Water pump	±1.10%	98.90%	0.04%
5	Solenoid valve	±0.76%	99.24%	0.01%

Source : Data of this study

Once the entire circuit has been paired and programmed in the Arduino IDE and has been uploaded to the ESP32. The final stage, maintenance is carried out by testing the entire system and system operation. The test consists of reading all sensors whose data is sent to the LCD display and Blynk dashboard, and automatic control of water taps and water pumps. Meanwhile, operations are carried out after all testing has been carried out.

The sensor data delivery test aims to determine the success of sending data from the sensor to the LCD display and Blynk dashboard. Testing is carried out by installing the system in the pool and the system is activated. When activated, it will immediately connect to the internet network and Blynk. Then the sensor detects the water parameters that will be processed to be displayed on the LCD and sends the data to Blynk.

From **Figure 5**, the data displayed on the Arduino IDE serial monitor, LCD, and Blynk application has been synchronized. Testing on the Blynk application has been carried out remotely, and data delivery can still be carried out.

Figure 5. Display on **(a)** Blynk dashboard, **(b)** LCD display, and **(c)** Serial monitor.

Automatic control testing aims to determine the success of sending data from sensors to the LCD and Blynk IoT and that the desired control synchronization is correct and can run. The process of changing the water in the catfish pond is carried out automatically using a solenoid valve and water pump.

The process of draining catfish pond water is carried out automatically using a solenoid valve. Testing is carried out by installing the system in the pool and the system is activated. To test, use water that has a low pH and water that has a normal pH. Then the pH sensor probe will be inserted into each water container in turn. The solenoid valve opens when the pH value of the water is less than 5.0. This is based on the fact that water acidity less than pH 5 will cause the growth of fungi and bacteria, so this must be treated immediately.

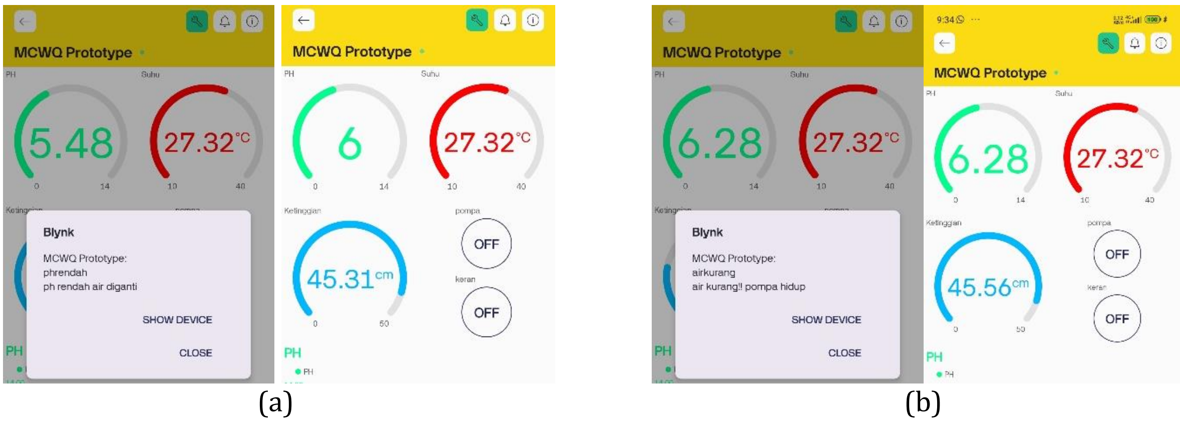

Figure 6. The results of control test **(a)** the solenoid valve, **(b)** the water pump.

It can be seen in **Figure 6(a)**, the results of the solenoid valve control test. The tap is open when the pH is low and closed when the pH is normal. However, when the tap is open based on a low pH it will close when the water has reached the minimum level. Once the water has reached the minimum level, the water pump will turn on.

The process of filling the catfish pond with water is done automatically using a water pump. The test is carried out by placing the distance sensor at a certain height to activate the water pump. The water pump turns on when the pool water level has reached the specified minimum limit, namely 10 cm during the test. Then, the water pump turns off when the water level reaches the maximum limit, namely 45 cm during the test.

It can be seen in **Figure 6(b)**, the results of the water pump control test. The water pump turns on when the water level is at the minimum level and will turn off when the water level reaches the maximum level.

Maintenance in system operation is carried out on a tarpaulin pool measuring 100 cm long by 100 cm with a height of 80 cm. all sensors are placed inside the pool, the solenoid valve is placed on the pool drain pipe and the water pump is outside the pool. The pool contains water with a height of 45 cm or the pool contains 450 liters of water. The running system monitors and controls pool water quality in real-time. This stage carried out data collection for 27 days. This operation aims to see whether the system can run well and can be used in the long term. Monitoring results taken via the Blynk application. The following **Table 2** is data on the results of system operation for 27 days.

Table 2. The results of System operation

No	Days to-	Date	Sensors Reading		
			pH Value	Temperature Value	Distance Value
1	1	6/1/2024	5.71	27.13	43.62
2	2	6/2/2024	6.10	26.63	43.83
3	3	6/3/2024	6.28	26.14	46.09
4	4	6/4/2024	6.47	27.17	45.18
5	5	6/5/2024	6.34	27.16	44.91
6	6	6/6/2024	7.03	27.68	45.26
7	7	6/7/2024	6.82	27.05	45.70
8	8	6/8/2024	6.73	27.25	46.20
9	9	6/9/2024	6.74	26.00	45.82
10	10	6/10/2024	6.92	26.77	45.90
11	11	6/11/2024	6.26	27.38	45.67
12	12	6/12/2024	7.11	27.19	45.97
13	13	6/13/2024	6.47	26.95	46.00
14	14	6/14/2024	6.57	27.39	45.42
15	15	6/15/2024	7.51	26.86	43.84
16	16	6/16/2024	6.70	25.70	50.01
17	17	6/17/2024	6.94	26.50	48.22
18	18	6/18/2024	6.96	26.89	49.42
19	19	6/19/2024	6.62	26.88	47.68
20	20	6/20/2024	7.29	26.75	47.66
21	21	6/21/2024	6.69	26.88	47.26
22	22	6/22/2024	7.09	24.88	50.69
23	23	6/23/2024	6.89	26.13	51.28
24	24	6/24/2024	6.79	27.13	51.15
25	25	6/25/2024	6.44	27.00	46.56
26	26	6/26/2024	5.17	27.38	46.70
27	27	6/27/2024	6.05	26.50	44.75

Source : Data of this study

It can be seen from **Table 2** that data from monitoring the effectiveness of the IoT-based water quality monitoring and control system can operate well and operate continuously or in real-time. This means that the system can be used effectively. The system can also be monitored remotely via the Blynk application (Nižetić et al., 2020). On **Figure 7** is a graph of changes in pH values every day for 27 days of system operation.

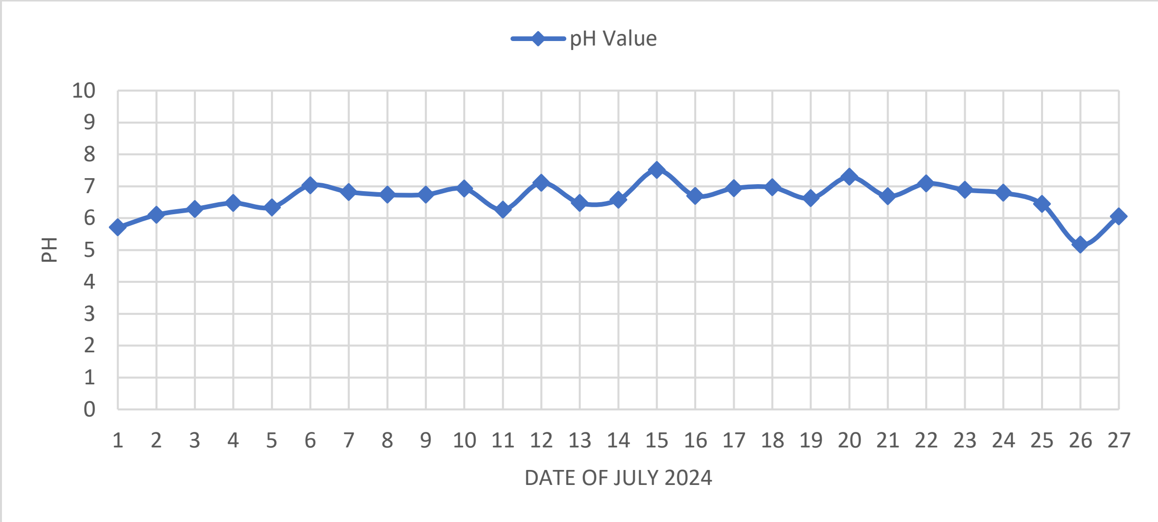

Figure 7. pH value chart from system monitoring results.

Data from measuring the pH of the water in catfish ponds are shown in **Figure 7**. On day 25, out of the 27 days the system was operating, there was an anomalous pH value. At that point, the pool's water was automatically adjusted by the control relay.

CONCLUSION

Pool water control system using ESP32, DS18B20 temperature sensor, 4502C pH sensor, 16x2 I2C LCD, water pump, solenoid valve, and Blynk IoT connection. The system will monitor water quality consisting of water acidity and water temperature. If the pH of the water is low, the solenoid tap will open to replace the water, after which the water pump will refill the drained pool. The function of the distance sensor is to measure the height of the pool according to the desired temperature and as a benchmark for closing the solenoid tap and opening/closing the water pump. Using an IoT-based water quality monitoring and control system can make it very easy to monitor and control the water quality of catfish ponds. Data that can be accessed via the Blynk application includes pH, temperature and pool water level as well as control of water pumps and taps from sensor readings. In this way, even though you are far from the pool, monitoring and control of pool water quality can still be carried out. The system provides real-time data to immediately determine the condition of the pool. An automated system reduces the need for manual intervention, increasing operational efficiency and pool maintenance. Additionally, the system can be used for any size and type of pond, from small ponds to large ponds or aquaponic systems. Sustainable research development can be carried out by re-analyzing the water quality that will be monitored and controlled. By expanding the water quality parameters that will be monitored and adding sensors to the system.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest concerning the publication of this article. The authors also confirm that the data and the article are free of plagiarism.

REFERENCES

Chafa, A. T., Chirinda, G. P., & Matope, S. (2022). Design of a real–time water quality monitoring and control system using Internet of Things (IoT). *Cogent Engineering*, *9*(1). https://doi.org/10.1080/23311916.2022.2143054

Dewantoro, W., & Ulum, M. B. (2021). Rancang Bangun Sistem Monitoring Kualitas Air Pada Budidaya Ikan Hias Air Tawar Berbasis Iot (Internet of Things). *Jurnal Komputasi*, *9*(2), 67–75.

Djamaludin, Kasoni, D., & Liesnaningsih. (2022). Prototype Robot Penyemprot Disinfektan Dengan Metode Research And Development. *JIKA (Jurnal Informatika)*, *6*(2), 135. https://doi.org/10.31000/jika.v6i2.5914

Hong, W. J., Shamsuddin, N., Abas, E., Apong, R. A., Masri, Z., Suhaimi, H., Gödeke, S. H., & Noh, M. N. A. (2021). Water quality monitoring with arduino based sensors. *Environments - MDPI*, *8*(1), 1–15. https://doi.org/10.3390/environments8010006

Ighalo, J. O., Adeniyi, A. G., & Marques, G. (2021). Internet of things for water quality monitoring and assessment: A comprehensive review. *Studies in Computational Intelligence*, *912*(September), 245–259. https://doi.org/10.1007/978-3-030-51920-9_13

Jan, F., Min-Allah, N., & Düştegör, D. (2021). Iot based smart water quality monitoring: Recent techniques, trends and challenges for domestic applications. *Water (Switzerland)*, *13*(13), 1–37. https://doi.org/10.3390/w13131729

Lakshmikantha, V., Hiriyannagowda, A., Manjunath, A., Patted, A., Basavaiah, J., & Anthony, A. A. (2021). IoT based smart water quality monitoring system. *Global Transitions Proceedings*, *2*(2), 181–186. https://doi.org/10.1016/j.gltp.2021.08.062

Mutri, M. A., Saputra, A. R. A., Alinursafa, I., Ahmed, A. N., Yafouz, A., & El-Shafie, A. (2024). Smart system for water quality monitoring utilizing long-range-based Internet of Things. *Applied Water Science*, *14*(4). https://doi.org/10.1007/s13201-024-02128-z

Nižetić, S., Šolić, P., López-de-Ipiña González-de-Artaza, D., & Patrono, L. (2020). Internet of Things (IoT): Opportunities, issues and challenges towards a smart and sustainable future. *Journal of Cleaner Production*, *274*. https://doi.org/10.1016/j.jclepro.2020.122877

Nugroho, E. (2007). *Kiat Agribisnis Lele*. Penebar Swadaya.

Okoli, N. J., & Kabaso, B. (2024). Building a Smart Water City: IoT Smart Water Technologies, Applications, and Future Directions. *Water (Switzerland)*, *16*(4). https://doi.org/10.3390/w16040557

Pasika, S., & Gandla, S. T. (2020). Smart water quality monitoring system with cost-effective using IoT. *Heliyon*, *6*(7), e04096. https://doi.org/10.1016/j.heliyon.2020.e04096

Pratama, I. P. Y. P., Wibawa, K. S., & Suarjaya, I. M. A. D. (2022). Perancangan PH Meter Dengan Sensor PH Air Berbasis Arduino. *JITTER- Jurnal Ilmiah Teknologi Dan Komputer*, *3*(2), 1–9.

Sanjaya, D., & Badarina, I. (2021). Pembuatan Kolam Pembudidayaan Lele Untuk Memotivasi Masyarakat Guna Meningkatkan Perekonomian Yang Terhambat Akibat Pandemi Covid-19 Di RT 1 RW 3 Desa Bukit Tinggi. *Journal Of Community Services*, *2*(2), 99–107. https://doi.org/https://doi.org/10.33369/tribute.2.2.99-107

Saparinto, C. (2013). *Budi Daya Ikan di Kolam Terpal* (Revisi). Penebar Swadaya.

Sugianti, E. P., & Hafiludin, H. (2022). Manajemen Kualitas Air Pada Pembenihan Ikan Lele Mutiara (Clarias gariepinus) di Balai Benih Ikan (BBI) Pamekasan. *Juvenil:Jurnal Ilmiah Kelautan Dan Perikanan*, *3*(2), 32–36. https://doi.org/10.21107/juvenil.v3i2.15813

Sugiyono. (2010). *Metode Penelitian Kuantitatif Kualitatif dan R&D*. Alfabeta.

Zulkifli, C. Z., Garfan, S., Talal, M., Alamoodi, A. H., Alamleh, A., Ahmaro, I. Y. Y., Sulaiman, S., Ibrahim, A. B., Zaidan, B. B., Ismail, A. R., Albahri, O. S., Albahri, A. S., Soon, C. F., Harun, N. H., & Chiang, H. H. (2022). IoT-Based Water Monitoring Systems: A Systematic Review. *Water (Switzerland)*, *14*(22). https://doi.org/10.3390/w14223621