International Journal of Multidisciplinary Approach Research and Science
E-ISSN 2987-226X P-ISSN 2988-0076
Volume 2 Issue 01, January 2024, Pp. 362-371
DOI: https://doi.org/10.59653/ijmars.v2i01.483

Freshwater Monitoring System Design in Real-Time for Fish Cultivation

Affan Bachri*
Universitas Islam Lamongan, Indonesia | affanbachri@unisla.ac.id
Correspondence Author*

Received: 05-12-2023 *Reviewed: 08-12-2023* *Accepted: 15-12-2023*

Abstract

The increased demand for fish supply in aquaculture highlights the need for sophisticated and accurate monitoring systems to ensure optimal water quality. In this context, Internet of Things (IoT) technology and fuzzy logic have become promising solutions to improve efficiency and effectiveness in freshwater fish farming. This research aims to develop a real-time freshwater monitoring system that integrates IoT and fuzzy logic. This system will enable monitoring of critical parameters such as temperature, pH and water turbidity with a high degree of accuracy. Implementation of IoT sensors that are connected to one centralized network and use fuzzy logic to process the data obtained. The research also involved developing an intuitive user interface to manage the system. The developed system is able to provide real-time monitoring with a high level of accuracy. Users can easily access and analyze the generated data through the user interface provided. The design of monitoring freshwater conditions for intensive aquaculture can be prepared using pH sensor devices, turbidity sensors, and temperature sensors using ESP2866 modules to connect to IoT. From the results of 20 days of system trials, it was found that the system can determine the condition of fresh water with good readings with average level of accuracy for pH sensors of 97%, turbidity sensors of 92% and temperature sensors of 96%.

Keywords: Fish Farming, IoT (Internet of Things), Water Quality, Fuzzy Logic, Real-Time Monitoring

Introduction

Aquatic animal production is anticipated to reach 178 million tonnes globally in 2020, a slight decrease from the record-breaking 179 million tonnes produced in 2018. (Figure 1). Aquaculture produced 88 million tons, and capture fisheries had 90 million tons (51 percent) (49 percent). 37 percent (66 million tons) of the total production is harvested in inland waters, while 63 percent (112 million tons) is harvested in marine waters (70 percent from capture fisheries and 30 percent from aquaculture). The first sales of the global production are expected to total USD 406 billion, of which USD 141 billion will come from capture fisheries and USD 265 billion from aquaculture.(FAO Fisheries and Aquaculture Department, 2022)

Several parameters that must be monitored routinely in water management for fish farming include; water temperature, oxygen content (dissolved oxygen), acidic or alkaline (pH), ammonia, Nitrite, plant nutrients, salinity and light (Robert R. Stickney, 2005).

Protein metabolism by aquatic organisms generally produces ammonia as a result of excretion. At the same time, the protein in the feces and uneaten feed will be broken down by bacteria into the same products. Thus the more intensive a cultivation activity will be followed by the higher the concentration of nitrogen compounds, especially ammonia, in water. So that the organisms being grown do not get sick, the amount of ammonia in the growing medium must be kept low. The most common method of limiting ammonia concentration in water is water exchange. This method, on the other hand, needs much water and can pollute the water around it if the water that is released is not treated further.Along with the development of intensive aquaculture systems, different ways of treating water to lower the amount of ammonia in the growing medium have also been created. One of these ways is biofloc technology.(Avnimelech, 2007)

Based on several previous studies, water conditions largely determine the results of fish farming. So it is very important to pay attention to the water quality monitoring system in fish farming, especially intensive fish farming in fresh water.

Recently, there has been a lot of research on freshwater monitoring systems for fish farming. Among them are ornamental fish, catfish, koi carps and shrimps. Various techniques are carried out both in simulation and prototyping. Some of the parameters studied include water temperature, pH level, water turbidity, salt content and others that support fish farming.

Research conducted by Agustin 2022 (Agustin et al., 2022), researching water condition monitoring in ornamental fish farming, in the study used Arduino as the main control and detected the temperature, pH and clarity of water by displaying notifications via telegram if the water conditions were not up to standard.

Ramadhona 2018 (Ramadhona & Hakim, 2018) This monitoring system uses Arduino uno as micro controller, equipped with ph sensor, temperature sensor, salinity sensor, LCD, and buzzer. The readable data will appear on the LCD and the buzzer will sound when one of the moisture levels is not at a standard number.

Anggara 2020 (Anggara Trisna Nugraha & Priyambodo, 2020) researching water monitoring in catfish farming, by utilizing LM35 as a water temperature sensor and LDR to detect water clarity. There is a water circulation pump when the water conditions are murky, the system is also equipped with a flowmeter to calculate the water rate when the circulation pump is on.

Ginanjar 2021 (Ginanjar et al., 2021) The koi fish smart farming prototype uses a Load Cell to determine fish feeding and RTC to detect pond temperature, using RTC as a temperature sensor and HX711 Load Cell for feeding detection in koi fish.

Budiman 2019 (Budiman et al., 2019) Monitoring and Control System for Ammonia and pH Levels for Fish Cultivation Implemented on Raspberry Pi 3B with ammonia and pH sensors.

Sneha 2017 (Sneha & Rakesh, 2018) The micro-controller will monitor the sensor values and these real-time values are shared to a data logging system implemented on a Raspberry Pi based single board computer. The real-time sensor values can be logged into the SD card of the Raspberry Pi. The actuators such as pump and aerator will be turned on and off automatically by the Raspberry Pi in accordance with the threshold values of different environmental parameters.

Some of them using the simulation for their research. Haiyunnisa 2016 (M. T. Haiyunnisa, 2016) Water quality controller simulation with mathlab. The output of the fuzzy logic controller is to decide the time interval of switches that run the blower and nano-mixing pump simultaneously to keep the eel fish aquaculture at the desired value for parameter temperature, pH, and Dissolved Oxygen. Shen 2009 (Shen et al., 2009) In this paper, a water environment monitoring system based on Back Propagation (BP) neural networks is presented, the data which uses multiple water factors to evaluate whether the water environment is suitable for shrimp growth like pH, temperature, dissolved oxygen (DO), salinity and so on.

In the study, data collection of freshwater conditions will use sensors that are placed directly in the pool. Some of the parameters of the water condition to be detected are; water temperature, water pH level, water clarity, and water conductivity level.

This study used fuzzy logic to determine water conditions. There are 3 water conditions, namely: good, medium and bad. Notifications on the condition of the fish can be read on smartphones and the web. It will also display the parameter level that has been read by the sensors placed in the pool in real time.

Literature Review

Observation of the water quality of aquaculture ponds is one of the things that can be done to increase the production of aquaculture. This can happen considering that water is the habitat and living place of fish. Thus, physical and chemical changes that occur in water will directly affect the growth and endurance of fish. Each of the fish has different physical prerequisites for water. For example, catfish can live in relatively cloudier water with low dissolved oxygen levels when compared to mujair fish. In the literature, there are several studies related to monitoring the water quality of aquaculture ponds in both pond and cage media. Some of the parameters observed include temperature, turbidity, pH, and dissolved oxygen (DO). The mechanism carried out is to take water samples to be then analyzed in the laboratory. In another study, David analyzed the prospects of the milkfish farming business in Tugu District, Semarang City. From the study, the fact was obtained that water quality can also affect the productivity of milkfish farms (Wijaya et al., 2016). Wilmar researching water quality in fish farming, the researcher proposed the design of a monitoring device consisting of microcontroller devices, pH and temperature sensors, and Ethernet communication modules. Although it can already make observations on small ponds, the system can cause problems if applied to large pools. This is because the communication module used is an Ethernet communication module that uses a cable as a communication medium so it is less flexible in terms of device placement (Borges et al., 2019). Thu ya Kwa conducting research in the field of smart aquaponics, the researcher proposed an intelligent aquaponic system by measuring water temperature, pH level, and light intensity (Hapsari et al., 2020). A summary of previous research can be seen in table 2.1.

Table 2.1: Previous Research about Water Quality Monitoring

Ref	Field	Sensor	Visualization	Communication	Processor	Remark
Wilmar - 2019 (Borges et al., 2019)	Fish culture	Temperature, pH, Turbidity		Modul ethernet	Mikrokontroller	Design only
Hapsari – 2020 (Hapsari et al., 2020)	Fish farming	pH, Salinity	Web		Raspberry pi	Equipped with response time test
Thu ya Kyaw - 2017 (Kyaw & Ng, 2017)	Smart aquaponic	Temperature, pH, Light sensor	Web	Wifi	Mikrokontroller, Raspberry pi	Water flow rate, light intensity
Taji khaoula- 2021 (Khaoula et al., 2021)	Aquaponic	Temperature, pH, TDS Sensor, EC sensor, soil moisture sensor, Ion sensor	MQQT	Wifi	ESP8266	Powered by a solar system, Design only
Meera prasad- 2020 (Prasad et al., 2020)	Fish farming	Temperature, pH, Water level sensor, light sensor	Firebase	Wifi	Mikrokontroller	Flood prediction
Jijin CK- 2016 (Jijin & Roshith, 2016)	Aquaponic	Temperature, Humidity, water detector, light sensor	Web browser		Lab view	

This study proposes to make design and implementation of freshwater monitoring for fish farming using sensors that are more complete than previous studies including dissolved oxygen sensors, water temperature sensors, pH sensors, and Turbidity sensors to get more optimal monitoring results so that it is hoped that more fish farming results will be obtained and better quality, besides that it will analyze the need for electrical power that will be used by the tool.

Some previous researchers also used fuzzy to help find solutions for their research, as shown in the table below.

Tabel 2.2. The originality of the research (State of The Art)

No	Principle	John R 2017 (Dela Cruz et al., 2017)	Triya Haiyunnisa, 2017 (T. Haiyunnisa et al., 2017)	Hanif Fakhrurroja, 2019 (Fakhrurroja et al., 2019)	Affan 2022
1	Field	Smart farm	water quality control	hydroponics	Fish Farming
2	Input Variables	pH, Soil moustere	DO, Temp	pH, humidity	pH, Temp, Turbidity
3	Method	Fuzzy logic	Fuzzy logic	Fuzzy logic	Fuzzy logic
4	System	Simulation	Simulation	Implementation	Implementation

John R (2007) proposes the design of an automated organic irrigation system in controlling and properly allocating the available water resources for the irrigation system and available electricity for the use of the pump. Experiments through MATLAB simulation were done using a proposed system to achieve the optimum water and electrical resource distribution. Likewise, Triya Haiyunnisa (2017) conducted a water quality control simulation. In 2019 Hanif Fahrurroja applied fuzzy logic in the field of hydroponics with pH and humidity as input variables. The author proposes the implementation of fuzzy logic in monitoring water quality in fish farming using water pH, temperature and turbidity as input variables.

Research Method

Several steps will be taken in this study to achieve the expected goals. Problem identification is carried out to review the problem to be solved. Problem identification is also a step to find system features, so that the system is able to provide the desired results. The main problem raised in this study is the mechanism for observing the quality of fish farming water in real time by minimizing the physical involvement of fish farmers. To overcome this problem, a pond water quality monitoring system is needed which consists of sensor devices equipped with communication capabilities to transmit data. Some parameters that need attention are the pH value of the water, water temperature, and pond water clarity.

The design and implementation of a freshwater quality monitoring system for ponds was carried out. This study utilized the ESP8266 communication module which is capable of supporting long-distance communication with low power consumption. This is important considering that the sensor node will be placed in a fish pond so that the node must be able to work using a standalone power supply from a battery. Furthermore, the gateway device forwards the data collected from all sensor nodes to the data center for further processing and analysis, the analysis is carried out using the fuzzy logic method. Cultivators can observe the water conditions of the aquaculture ponds in real time from a web-based application. Furthermore, if an anomaly occurs, the data center can send notifications and treatment suggestions to farmers via the web or application.

Testing and analysis of results needs to be done to ensure that the system is working properly and as planned. Testing is carried out in stages, starting from small parts of the system such as testing the pH sensor, temperature sensor and turbidity sensor which are carried out independently. After that, the overall fresh water monitoring system was tested.

The last step is making conclusions to conclude the results of the research that has been done. In Figure 3.1, you can see the block diagrams of the stages that will be carried out in the study.

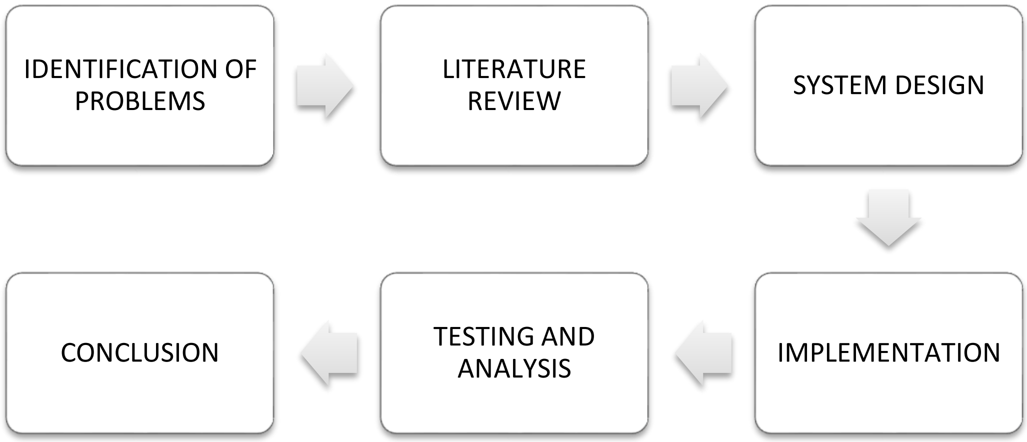


Figure 3.1: Block diagrams of Research Methodology.

Based on the problems studied, this system must have several functional needs including: The sensor node device is able to obtain data from the water physical condition observer sensor with several parameters including: pH, turbidity and water temperature. The sensor node device is capable of transmitting acquired data to the gateway device using the ESP8266. The gateway device is capable of receiving sensor data and subsequently forwarding that data to the datacenter. Data centers are capable of receiving, storing and processing sensor data obtained from gateway devices.

System design is a stage in planning system implementation based on the needs of this research. The system architecture designed in this study can be seen in Figure 3.2.

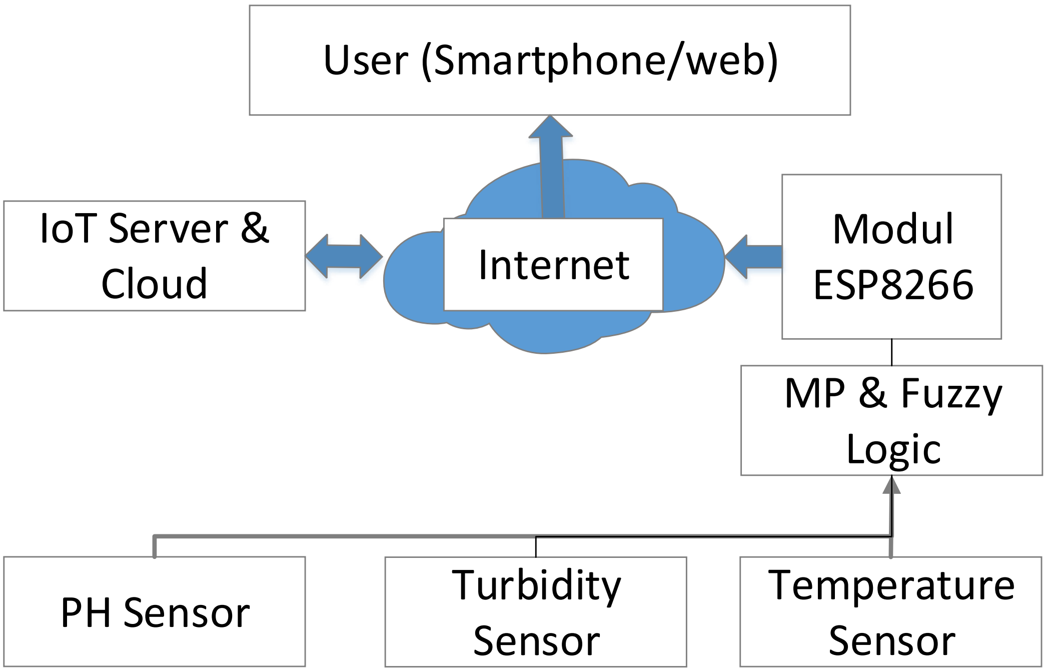
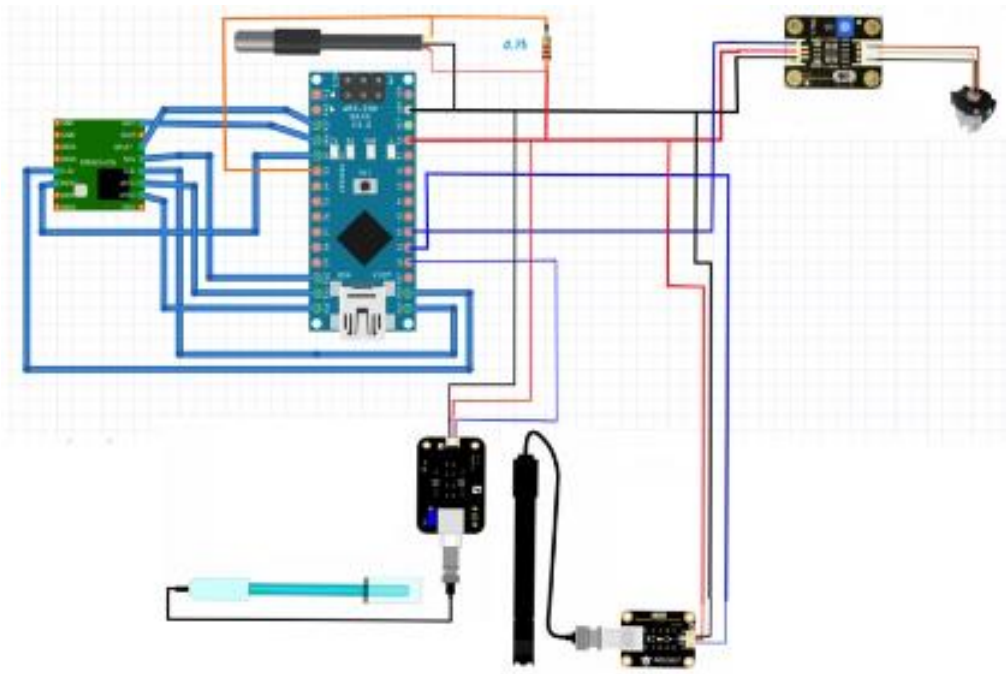


Figure 3.2: System Architecture Design.

Result and Discussion

In this section will be explained about the implementation of the components that make up the system. Sensor node devices have an important role to acquire data on the physical condition of water including pH, dissolved oxygen, temperature and turbidity of water. The data is then sent to the gateway device using the ESP8266 communication module.



Picture 3.4. Electronic Circuit schematic designed tools

The sensor component plays a role in detecting the physical condition of water which includes four parameters, namely the level of acidity (pH), dissolved oxygen, temperature and turbidity level. To meet these needs, researchers utilize several types of sensors, including: DS18B20 Waterproof Water Temperature Sensor to measure water temperature. Sensor pH Meter to measure the acidity of water. Turbidity Sensor to measure the degree of turbidity of water. The reading data from these sensors is then processed and acquired by the microprocessor device. Next, the sensor data is sent to the gateway device using the ESP8266 communication module.

Testing of the designed system for 20 days, then the readings of the tool are compared with manual measuring instruments to determine the accuracy of readings by the designed tools compared to manual measuring instruments. So that the results are obtained as shown in table 2.3. below:

Table 2.3. Test results of designed tools

Day to	Water pH			Turbidity			Water Temperature		
	Designed tools	pH meter	Accuracy %	Tools	Turb. Meter	Accuracy %	Tools	Thermo meter	Accuracy %
1	7.4	7.7	96	43.7	48.0	91	27.1	28.2	96
2	7.5	7.6	99	195.7	198.0	99	27.5	28.5	96
3	7.5	7.8	96	106.7	110.0	97	26.9	28.4	95
4	7.6	7.9	96	35.7	38.0	94	26.8	27.10	99
5	7.6	7.8	97	261.7	266.0	98	24.8	25.10	99
6	7.5	7.7	97	117.7	120.0	98	27.3	28.3	96
7	7.5	7.8	96	77.7	81.0	96	27.2	28.7	95
8	7.4	7.7	96	43.7	46.0	95	27.3	28.4	96
9	7.4	7.6	97	32.7	37.0	88	27.5	28.6	96
10	7.4	7.7	96	53.7	56.0	96	27	28.0	96
11	7.3	7.6	96	25.7	29.0	89	25.4	26.10	97
13	7.6	7.8	97	34.7	37.0	94	26.4	27.6	96
14	7.4	7.7	96	30.7	35.0	88	24.9	26.1	95
15	7.3	7.6	96	32.7	35.0	93	27.4	28.5	96
16	7.8	8.1	96	32.7	36.0	91	26.2	27.8	94
17	7.5	7.7	97	29.7	32.0	93	27.7	28.9	96
18	7.4	7.7	96	14.7	19.0	77	26.2	27.4	96
19	7.3	7.6	96	16.7	19.0	88	27	28.0	96
20	7.6	7.8	97	12.7	16.0	79	26.8	28.3	95
Average accuracy			97	Average accuracy		92	Average accuracy		96

From the table of system test results it is said that the designed tool works well with an average level of accuracy for pH sensors of 97%, turbidity sensors of 92% and temperature sensors of 96%.

Conclusion

The design of monitoring freshwater conditions for intensive aquaculture can be prepared using pH sensor devices, turbidity sensors, and temperature sensors using ESP2866 modules to connect to IoT. From the results of 20 days of system trials, it was found that the system can determine the condition of fresh water with good readings with average level of accuracy for pH sensors of 97%, turbidity sensors of 92% and temperature sensors of 96%.

References

Agustin, M., Zain, A. R., Soelaiman, N. F., Oktivasari, P., Bohan, J. R., Karim, M. A., Anshor, F., & Fahroji, M. F. (2022). *The Aquarium Monitoring System Design and Prototype for Ornamental Fish Farmers using NodeMCU with Telegram Data Notifications*. 162–166.

Anggara Trisna Nugraha, & Priyambodo, D. (2020). Design of Pond Water Turbidity Monitoring System in Arduino-based Catfish Cultivation to Support Sustainable Development Goals 2030 No.9 Industry, Innovation, and Infrastructure. *Journal of Electronics, Electromedical Engineering, and Medical Informatics*, *2*(3), 119–124. https://doi.org/10.35882/jeeemi.v2i3.6

Avnimelech, Y. (2007). Feeding with microbial flocs by tilapia in minimal discharge bio-flocs technology ponds. *Aquaculture*, *264*(1–4), 140–147. https://doi.org/10.1016/j.aquaculture.2006.11.025

Borges, W., Junior, L., Nunes, R. M., Andrade, L. De, Cordeiro, Í., Lima, S., Fiuza, L. S., & Dias, M. (2019). *Development of a Low-Cost System for Monitoring Water Quality applied to Fish Culture*. *6495*(7), 1–5.

Budiman, F., Rivai, M., & Nugroho, M. A. (2019). Monitoring and Control System for Ammonia and pH Levels for Fish Cultivation Implemented on Raspberry Pi 3B. *Proceedings - 2019 International Seminar on Intelligent Technology and Its Application, ISITIA 2019*, 68–73. https://doi.org/10.1109/ISITIA.2019.8937217

Dela Cruz, J. R., Magsumbol, J. A. V., Dadios, E. P., Baldovino, R. G., Culibrina, F. B., & Lim, L. A. G. (2017). Design of a fuzzy-based automated organic irrigation system for smart farm. *HNICEM 2017 - 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management*, *2018-Janua*, 1–6. https://doi.org/10.1109/HNICEM.2017.8269500

Fakhrurroja, H., Mardhotillah, S. A., Mahendra, O., Munandar, A., Rizqyawan, M. I., & Pratama, R. P. (2019). Automatic pH and Humidity Control System for Hydroponics Using Fuzzy Logic. *2019 International Conference on Computer, Control, Informatics and Its Applications: Emerging Trends in Big Data and Artificial Intelligence, IC3INA 2019*, 156–161. https://doi.org/10.1109/IC3INA48034.2019.8949590

FAO Fisheries and Aquaculture Department. (2022). The State of World Fisheries and Aquaculture 2022.Towards Blue Transformation. In *In Brief to The State of World Fisheries and Aquaculture 2022*. https://doi.org/10.4060/cc0463en

Ginanjar, P., Opipah, S., Rusmana, D., Muhlas, Effendi, M. R., & Hamidi, E. A. Z. (2021). Prototype Smart Fish Farm in Koi Fish Farming. *Proceeding of 2021 7th International*

Conference on Wireless and Telematics, ICWT 2021, 0–5. https://doi.org/10.1109/ICWT52862.2021.9678208

Haiyunnisa, M. T. (2016). *Water Aquaculture Based Fuzzy Logic : MATLAB Based Simulation Approach*. 1–5.

Haiyunnisa, T., Alam, H. S., & Salim, T. I. (2017). Design and implementation of fuzzy logic control system for water quality control. *Proceedings of the 2nd International Conference on Automation, Cognitive Science, Optics, Micro Electro-Mechanical System, and Information Technology, ICACOMIT 2017*, *2018-Janua*, 98–102. https://doi.org/10.1109/ICACOMIT.2017.8253394

Hapsari, G. I., Wakid, Z., & Mudopar, S. (2020). *IoT-based guppy fish farming monitoring and controlling system*. *18*(3), 1538–1545. https://doi.org/10.12928/TELKOMNIKA.v18i3.14850

Jijin, C. K., & Roshith, K. (2016). *ONLINE MONITORING AND CONTROL AQUAPONICS USING LAB VIEW*. 23–27.

Khaoula, T., Abdelouahid, R. A., Ezzahoui, I., & Marzak, A. (2021). Architecture design of monitoring and controlling of IoT-based aquaponics system powered by solar energy. *Procedia Computer Science*, *191*, 493–498. https://doi.org/10.1016/j.procs.2021.07.063

Kyaw, T. Y., & Ng, A. K. (2017). ScienceDirect ScienceDirect ScienceDirect The 15th Aquaponics International Symposium System Urban Thu Ya Kyaw of Assessing the feasibility using Keong the heat function for a long-term district demand forecast. *Energy Procedia*, *143*, 342–347. https://doi.org/10.1016/j.egypro.2017.12.694

Prasad, M., Majeed, S., Romichan, S., Mathew, W., & Udaybabu, P. (2020). *Cost Effective IoT based Automated Fish Farming System with Flood Prediction*. *9*(1), 291–297.

Ramadhona, M. D., & Hakim, D. L. (2018). System of Water Quality Monitoring and Feeding on Freshwater Fish Cultivation. *IOP Conference Series: Materials Science and Engineering*, *384*(1). https://doi.org/10.1088/1757-899X/384/1/012034

Robert R. Stickney. (2005). *Aquaculture: An Introductory Text* (S. G. C. P. T. A. & M. U. Usa (ed.)). Cabi Publishing-Sea Grant College Programme Texas A & M University.

Shen, X., Chen, M., & Yu, J. (2009). Water environment monitoring system based on neural networks for shrimp cultivation. *2009 International Conference on Artificial Intelligence and Computational Intelligence, AICI 2009*, *3*, 427–431. https://doi.org/10.1109/AICI.2009.294

Sneha, P. S., & Rakesh, V. S. (2018). Automatic monitoring and control of shrimp aquaculture and paddy field based on embedded system and IoT. *Proceedings of the International Conference on Inventive Computing and Informatics, ICICI 2017*, *Icici*, 1085–1089. https://doi.org/10.1109/ICICI.2017.8365307

Wijaya, D. P., Elfitasari, T., & Sarjito. (2016). ANALISA PROSPEK BISNIS BUDIDAYA PEMBESARAN IKAN BANDENG (Chanos chanos) DI KECAMATAN TUGU KOTA SEMARANG. *Journal of Aquaculture Management and Technology*, *5*(3).