Implementation Of IoT In Nila Fish Cultivation With Bioflock System

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Abstract—In cultivating tilapia using the biofloc system, maintaining water quality (temperature, pH, turbidity) is not only for the health of the fish but also for the reproduction of the biofloc. So that water quality is known, sensors connected to IoT are installed. Sensor output data is processed by Arduino and sent to a data base server via the internet network so that water quality parameters can be monitored at any time via the internet network. This system was created in research entitled "Optimizing Tilapia Cultivation of Biofloc Systems with the Internet of Things". The pool has a diameter of 2m, height 1m, airator 500 liters/min, 4 airstones @ 30 liters/min. After the pond is assembled and the biofloc has grown (made from 375 ml multi-probiotic, 300 ml molasses, 150 gram dolomite, 60 gram nitrobacter), proceed with adding 150 tilapia fish seeds 5-6 cm long (weight 22.2 gr/fish). After 2 months the growth of the tilapia became 12-13 cm long (weighing 100 g/fish), with 2% mortality. The sensor measurement results displayed on the website are as follows: average pH values (5.6-7.5), temperature (27-29), turbidity (225-354) ppm, floc density (20-25) ml/liter. Hiprofit 781-3 feed is 13.4 kg. The research results show that IoT implementation can display the water quality of biofloc tilapia ponds in real time. pH fluctuations from 5.6-7.5 indicate that biofloc can function well.

Keywords: IoT, Nila fish, bioflog, water quality.

1. Introduction

The Ministry of Maritime Affairs and Fisheries (KKP) through the Directorate General of Aquaculture (DJPB) in collaboration with researchers from the Bogor Agricultural Institute (IPB) has succeeded in implementing the biofloc system Tilapia fish cultivation technology. The implementation and development of Tilapia cultivation in the biofloc system is the result of continuous innovation carried out by DJPB regarding effective and efficient technology, including the use of water and land resources and being able to adapt to climate change. The biofloc system of tilapia cultivation is a method of cultivating tilapia which generally uses tarpaulin ponds as a medium for water. To maintain water quality, biofloc is a collection of various organisms (bacteria, fungi, algae, protozoa, worms, etc.), which are combined into a floc (Suprapto and Legian, 2013). Biofloc can be formed if there are 4 components, namely a carbon source, organic material from food waste and fish waste, decomposing bacteria and oxygen availability. The formation of biofloc occurs through stirring organic material by aeration so that it dissolves in the water column to stimulate the development of aerobic heterotrophic bacteria that attach to organic particles, decompose organic material, then absorb minerals such as ammonia, phosphate and other nutrients in the water. So that beneficial bacteria will reproduce well. The result is that water quality improves and organic material is recycled into floc that can be eaten by fish. Some of the advantages of cultivating tilapia using a biofloc system:

a. Water saving does not need to be replaced frequently because bacterial colonies can break down fish waste into nutrients that can be reabsorbed by fish.
b. Increasing productivity, bacterial colonies also provide additional nutrition for fish so that they can increase fish growth and productivity.
c. Cost effective, because 90% of the water does not need to be replaced, so costs for water replacement are low and treatment of fish diseases can be saved.
d. Environmentally friendly, because it doesn't throw a lot of waste into the surrounding environment. Apart from that, this system also does not use antibiotics and chemicals that have the potential to damage the environment..

Literature review

Estu Nugroho, (2021) said "Fish cultivation using biofloc technology (BFT) which saves land and water is very suitable for development in urban areas or densely populated residential areas which are also a market for the products produced. The productivity level of BFT tilapia is to reach a production level of 40 kg/m3 of water. "With a maintenance period ranging from 2-4 months, it is estimated that this BFT will be a breakthrough apart from supporting food security programs in the context of sufficient protein supply and can be used as a more dignified alternative livelihood." Tilapia cultivation using a biofloc system requires a stable pH and temperature so that the decomposing bacteria can work effectively. pH conditions that are too high or too low can inhibit bacterial growth and cause fish death. The pH of the water in biofloc tilapia cultivation should be maintained in the range of 6.5 to 8.5. Meanwhile, the water temperature in the biofloc pond is maintained at around 25-32 degrees Celsius.

The problems that occur in cultivating tilapia using the biofloc system are:

a. water quality including temperature and pH can change, while farmers do not know and are not aware of these changes;
b. the number of biofloc (Nitrosomonas and Nitrobacter bacteria) can be reduced or too much, due to inappropriate feeding;
c. the amount of ammonia is too high and unknown to farmers;
d. When the PLN goes out, the aerator does not work, so the amount of dissolved oxygen in the water is not sufficient for the tilapia's oxygen needs.

Due to limited knowledge and capabilities, measurements of water quality parameters are not carried out or are only carried out when serious problems occur so that treatment is delayed which results in poor harvest results and even crop failure.

Based on the description above, the problems in cultivating tilapia in biofloc ponds can be formulated as:

a. how to monitor water quality parameters continuously by presenting real time data and making it easy for farmers to know quickly;

b. how to maintain water quality parameters always within standard values;
c. how can farmers know when to stop feeding fish;

2. System Planning and Design

This research was carried out in several stages, namely literature study and initial investigation, hardware design with an Arduino control center, web and database server design, calibration and testing by collaborating with partners who manage the tilapia cultivation system biofloc, refinement and documentation. This method is depicted in Figure 2.1 below.

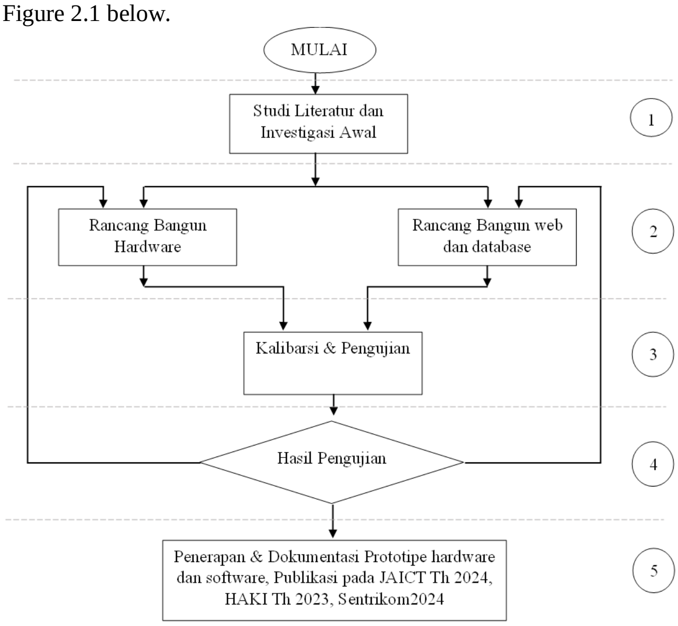

Figure 2.1. Research method flow diagram

At this stage, observations are made about where the system will be placed, the security of the system, and what needs are needed to build the system.
From Figure 2.1, this research was carried out in 5 stages, with an explanation of each stage as follows:

Stage 1, an initial investigation is carried out looking for physical data on the size of the biofloc pond and a site visit to the location of the biofloc pond. Then a literature study was carried out regarding ideal data on ideal measurement values as a basis for hardware design, temperature measurement, pH measurement, DO measurement and measuring the number of biofloc in the pond. The sensor is connected to an Arduino microcontroller and selects a suitable 4G LTE network to send measurement data to the database.

Stage 2, based on initial investigations and the results of literature studies, hardware, web and database design and creation are carried out.

Hardware manufacturing includes:
a. making equipment for measuring temperature, pH, and biofloc levels in ponds;
b. assembling biofloc ponds and installing clean water installations;
c. solar cell and water pump installation;

Web and database creation includes:
a. creating websites and databases on local servers;
b. hosting and domain rental followed by web and database creation on server hosting;
c. assembling a data network via 4G LTE to send data to a data base server;

To build a web and database, start by designing a data flow diagram (DFD), including the types of users and what data each user needs. The design of the Data Flow Diagram (DFD) for the water condition monitoring system in biofloc tilapia ponds with IoT is shown in the following figure 2.2.

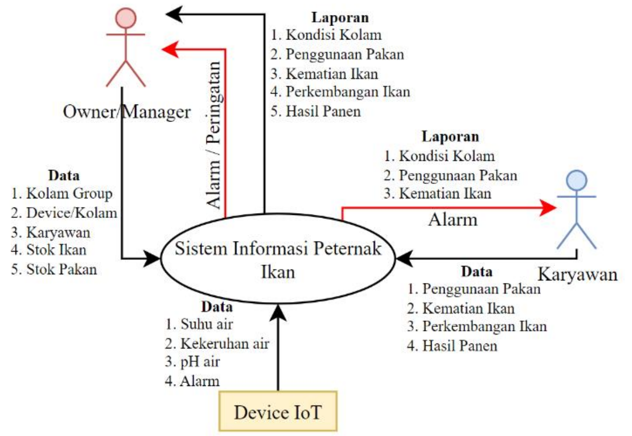

Figure 2.2. Data Flow Diagram (DFD)

Based on the DFD, the table requirements and contents of each table as well as the relationships between tables are designed. Measurement data including temperature, pH, and ammonia levels are stored in a server database using MySQL. The relationship between tables is shown in figure 2.3. following.

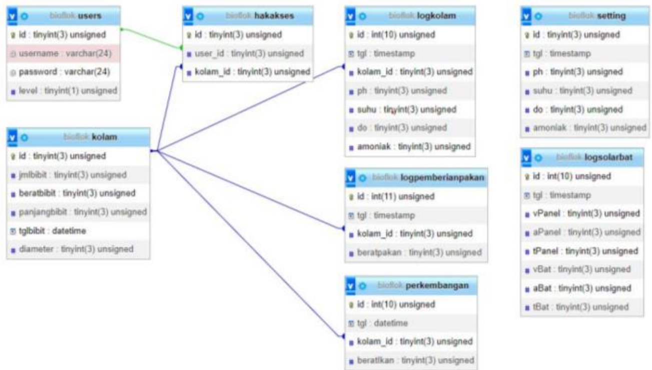

Figure 2.3. Relationships between tables in a MySQL database

Later the data will be generated from sensor measurements data is compared with standard data for each parameter to maintain biofloc pond water quality in real-time.

Stage 3, at this stage testing is carried out:
a. measurement and calibration equipment functions;
b. Before the test is carried out, the temperature, DO, pH and biofloc content sensors are calibrated. Calibration is carried out using the standard calibration method for each sensor connected to the Arduino, namely by setting the offset value for each. For pH calibration, a standard calibration solution is used. To calibrate the measurement of the number of biofloc using a turbidity meter and water taken from a mature biofloc pond. The obtained value is used to set the Arduino offset value. To calibrate the measurement of dissolved oxygen levels in water, solutions with different dissolved oxygen levels are used, used to determine the offset value of the Arduino program.
c. data sending function to data base with ESP 8266 and G LTE; This test can be carried out with dami data which represents the value of each sensor. Dami data is generated directly by Arduino and then sent to the database server via ESP 8266 and 4GLTE. This step is carried out after the MySQL database is created on the hosting server. Web function to display measurement data, as well as notification function if data is found whose value is outside the ideal value;

The hardware device used to measure water quality and send measurement results data to a web data base is shown in Figure 2.4 below.

Figure 2.4. Measurement pH, Temperature, Turbidity

2.1 Web Design

The web hosting in this research is planned to have the domain name smartbioflok.com, with the url address http://smartbioflok.com, to enter the web through user authentication. After successful login, the main page will be displayed as shown in Figure 2.5. below.

Figure 2.5. Display the main web page

The web page built in this research is only for monitoring one biofloc pond, but it has been designed to be developed to monitor up to 8 biofloc ponds. The results of monitoring water parameters are displayed in numbers and graphs. The numerical display is on the right side of the page, while the graphic display is on the right. The web page provides options for displaying the data you want to see, namely minutes, hours, days, weeks, months and years. With this option, users can analyze the relationship between water quality parameters and observations of fish conditions.

Stage 4, is part of the test, namely measuring or knowing the difference between deviations from the test results and the planned conditions. If there are still differences, repair the hardware and web and data base, and test again until the condition is perfect. The next step is to place all the sensors in a bioflog pond that already has tilapia and biofloc (figure 2.6).

Figure 2.6. Sensors in a bioflog pond

In this test, all data from each sensor is sent to the database by the ESP 8266 alternately with a duration of 30 seconds for each sensor. Sending measurement data to a database server and retrieving data by computer or cellphone devices via the telecommunications network infrastructure shown in Figure 2.7. below.

2.2 Infrastucture Telecommunication Network

Figure 2.7. Research IoT Network Infrastructure

To measure the pH of pool water, a pH sensor is used which is capable of measuring pH from 0 to 18, shown in figure 2.8

Figure 2.8. Sensor pH

To measure the turbidity of pool water, using a turbidity sensor that is compatible with a micro controller with logic voltage level 5V. shown in figure 2.9.

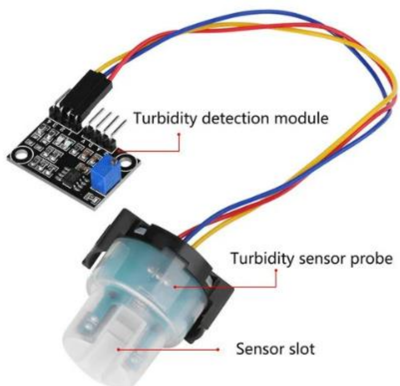

Figure 2.9. Turbidity sensor

To measure the temperature of the pool water, a temperature sensor is used which is capable of working at temperatures of -50 to 125 degrees Celsius, shown in Figure 2.10.

Power Supply Range: from 3.3V to 5V. Temperature Sensor Output Instructions: yellow (VCC), red (DATA), black (GND). High quality stainless steel waterproof probe. The sensor cable is soft, which has better oxidation resistance ability. Has better thermal conductivity.

Figure 2.10. Sensor temperature

The method of storing data in a database is done by comparing the data received with the data stored in the database. If there are changes then the data is saved, if there are no changes the data is not saved. This process is carried out continuously until the fish is harvested. From figure 3.7. It is shown that four sensors are included in the biofloc pond, namely number 1 to number 4. To maintain DO levels, an air stone is used which is connected to an air pump which works for 24 hours. Besides the main air pump, there is a standby air pump which is turned on during an emergency. DO levels can decrease if there is too much ammonia in the water, to increase DO by removing the water and adding clean water. At that time, the air pump should still work because the power supply is taken from the battery that is in the charger control unit. In this test, it is recorded how long the battery can last to supply the air pump and IoT system, as a basis for determining the ideal battery capacity. In all stages of testing, the condition of the tilapia fish was also observed, whether it remained in the water or took in air at the surface of the water. If it is found that the tilapia fish are taking air from the surface of the pond water, this is a sign that the fish is lacking oxygen, then this data is entered via the GUI into the data base. And initial data on fish lacking oxygen will be documented and presented together with data on pH, number of biofloc and temperature. This data will be very useful for improving the quality of tilapia cultivation in biofloc ponds.

To reading and transmit data from the sensor to the database server, the ESP 32 is used as a connector to the internet network via WiFi, shown in Figure 3.11. below.

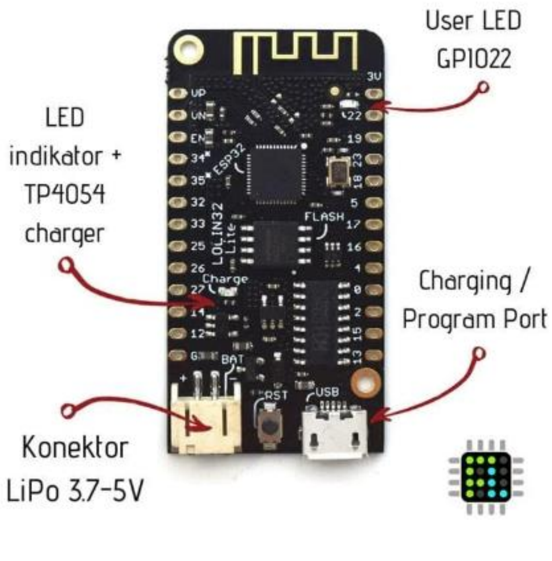

Figure 2.11. ESP 32 to read and trasmit data

Biofloc cultivation systems can use several types of containers. These include concrete pools, fiber pools and tarpaulin pools provided they do not form corners. The following is the preparation of a cultivation container using a round tarpaulin pond container. The tools and materials used for round pools are: woven iron (8-10 mm diameter wiremesh iron) for the pool frame with a diameter of 2 m, thin fiber/carpet gutter/2 mm plywood as a wall covering, tarpaulin made from terpoline (trademark: Orchid) for the walls and bottom of the pool (you can use tarpaulin that has been formed), 2 inch PVC pipe and 2 L joints, glue, scissors, hacksaw, blower (recommended trademark: Yasunaga), aeration hose (as needed), stones aeration measuring 14 cm, paranet (if the pool is in an open area or not covered).

Figure 2.12. Preparation of a cultivation container

The stages of making a tarpaulin pool are:

Cut the woven iron (wiremesh) to the desired size, then connect each part/book using an iron ring/wire hook to form a circle; Make the base of the pool by leveling the ground surface then install the center pipe according to the size of the pool; Then install wall coverings so that the pool tarpaulin does not leak easily; Next, install the pool tarpaulin by adjusting the size of the pool then locking and tying it tightly; Install and arrange sewer pipes;

Figure 2.13. Making a tarpaulin pool

Next, install an aeration system by adjusting the number of points in each pool with a good pressure of 30 liters/minute/aeration point/m^3. Dissolved oxygen or Dissolved Oxygen is usually abbreviated as DO or often also called oxygen demand, namely the amount of oxygen dissolved in water. The DO value which can generally be known in concentration and unit format is the amount of oxygen (O2) available in a body of water. The greater the DO content in water, it indicates that the water has good water quality. On the other hand, if the DO content is low, it is a sign that the water is polluted.

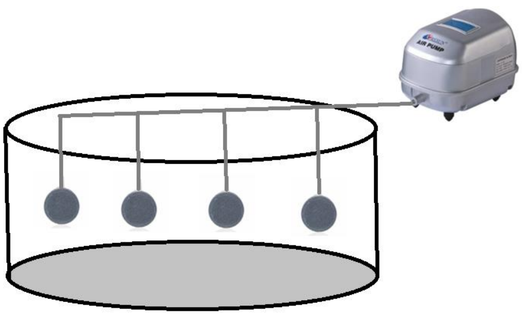

Figure 2.14. Airpump with airstone

Figure 2.15. Aeration system

To supply dissolved oxygen needs, an air pump with a capacity of 1500 liters/hour is used, with 4 flat air stones with a diameter of 10 cm installed at 4 point positions which allows air to spread evenly into the water.

Media Preparation biofloc

Preparing maintenance media in a biofloc system is very important. Where the preparation of the media water used in the biofloc system determines the success of this system because the biofloc system utilizes the presence of bacteria as the main component that forms floc bacteria (clumps of white foam), so the media preparation must be done correctly.

The tools and materials used in preparing the media (1 m3 of water) are:

a. Water to fill the pool.
b. Sea salt 1kg/m^3.
c. Molasses 100 ml/m^3 or granulated sugar 100 grams/m3.
d. Probiotics 10 gr/m^3.
e. Dolomite lime 50 gr/m^3.

Figure 2.16. Insert biofloc starter bacteria

The media preparation stages can be carried out in stages, namely:

a. Fill the pond with water to a height of 80 cm and aerate it;
b. Add the dissolved salt;
c. Then dissolve the dolomite lime and add it to the pond media;
d. Next, add the molasses that has been dissolved in water;
e. Next, add the probiotics that have been dissolved in water into the pool.

Stage 5, is the implementation, namely by operating the prototype in a biofloc pond with IoT, from the start, filling clean water, the process of growing biofloc, inserting fish seeds until harvest. "After the pool is filled with water and the aeration stones are arranged so that oxygen can be evenly distributed throughout the water column of the pool. The oxygen flow was set at a speed of 10 L/minute. The ingredients for making biofloc media are 1 kg/m3 krosok salt, 50 gram/m3 dolomite lime, 100 ml/m3 molasses, probiotics with the bacterial composition Baccilus sp. 10 ml/m3 (using a combination of multi cells and bioflocculant). Each of these ingredients is sequentially dissolved in water and put into the pool. Leave the pond for 7-10 days or until the pond walls feel slippery when touched, which indicates that the biofloc has grown. Water quality is measured and maintained at a minimum dissolved oxygen (DO) content of 3 mg/L and ranging between pH 6.5-8.5 and the temperature is maintained between 25-32 degrees Celsius, water color is also observed. Tilapia fish seeds are put into the pond with a planned density of 100 fish/m3. Fish are fed 2x24 hours at a dose of 3% of the fish's body weight.

To treat water during maintenance is as follows:

a. Molasses and probiotics are added if oxygen levels approach 3 mg/L.
b. Dolomite is added if there is a change in water pH of around 5.
c. The biofloc media water should be brownish in color.
d. The flock volume is maintained at 50 ml/L and if the flock is too dense, feeding is stopped.
e. Water is added when evaporation occurs.

Then continue with evaluation of the measurement data stored in the data base is carried out, as information for managers of tilapia cultivation in one harvest season, how the correlation between biofloc, pH, temperature and ammonia at each age of fish growth is carried out. Apart from that, the amount of fish food for one harvest season in one biofloc pond is also recorded, evaluated and the operational costs and profits are calculated. Next, documentation of data from measurements of biofloc pond water quality is carried out, documentation of prototypes of design results for temperature and pH measurement equipment, including sensor types and specifications, block circuit diagrams, system installation and calibration. Documentation of DO, temperature, pH control system performance. Web and data base software coding documentation.

Figure 2.17. Measurement data stored in the data base

3. Test Results and Analysis

At this stage, we carry out a detailed analysis of the measurement data obtained during the research period. Measurements are carried out periodically on several key parameters relevant to tilapia cultivation using a biofloc system optimized with the Internet of Things (IoT).

Sensor testing is a critical stage in implementing a water condition monitoring system in biofloc tilapia ponds with the Internet of Things (IoT). These testing steps aim to ensure the accuracy, reliability and consistency of the data produced by the sensors installed in the fish pond.

Sensor testing is carried out by comparing the measurement results with tools made by the factory, The results are shown in Table 1.

Table 1. Sensor Accuracy Test

Test	pH	Temp	pH meter	Temp Meter	Error Sensor PH	Error Sensor Temp
1	5,25	28,74	5,1	29	2,94%	0,90%
2	5,2	28,4	5,1	28,7	1,96%	1,05%
3	5,22	28,4	5,1	28,7	2,35%	1,05%
4	5,06	28,4	5,1	28,7	0,78%	1,05%
5	5,17	28,4	5,1	28,7	1,37%	1,05%
6	5,09	28,5	5,1	28,7	0,20%	0,70%
7	5,12	28,7	5,1	28,7	0,39%	0,00%
8	5,17	28,7	5,1	28,7	1,37%	0,00%
9	5,16	28,7	5,1	28,7	1,18%	0,00%
10	5,14	28,7	5,1	28,7	0,78%	0,00%

The results of water quality measurements show that parameters such as temperature, pH and dissolved oxygen remain within the optimal range for the growth and health of tilapia. IoT systems enable real-time monitoring and automatic control of water quality parameters, resulting in a stable environment and supporting optimal growth of fish.

Based on the test data in table 1, the largest error sensor pH value is 2.94%, this shows that the IoT system can display fairly accurate measurement values.

Calibration is carried out by comparing IoT measurement results with measuring instruments made by factories and circulating on the market which are often used for measurements.

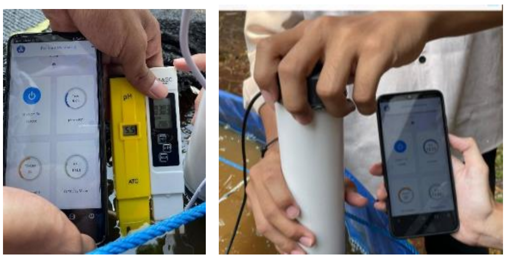

Figure 3.1. Calibration of measuring instruments

The measurement results data is displayed on a web page, which is shown in the following figure 3.2. below.

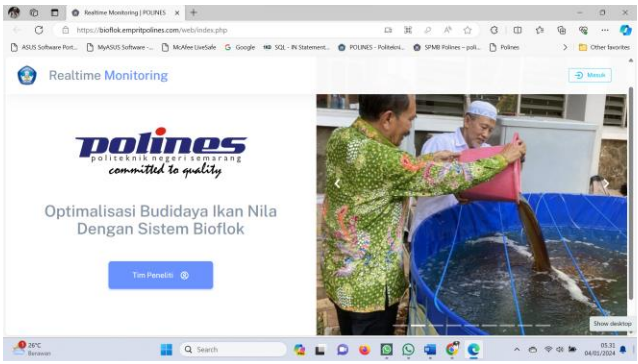

Figure 3.2. Website IoT Biofloc

The web display with a background includes ingredients (molasses, probiotics, dolomite lime, decomposing bacteria) that have been mixed to grow biofloc. When adding these materials, the pool must already have an oxygen generation system which is dissolved into the water with an air stone. Biofloc growth takes around 10 days to 14 days with the pond kept out of direct sunlight

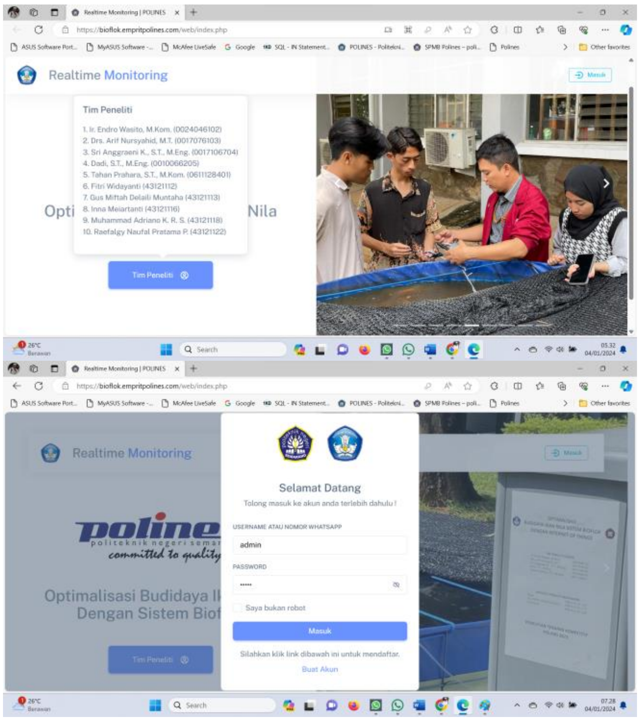

Figure 3.3. Display the web

After entering the username and password into the information system web, an information page displays the results of temperature, pH and turbidity measurements. The pH, temperature and turbidity measurement results displayed are real time measurement data and are stored in a database and can be viewed via a cellphone or laptop connected to the internet network. Shown in Figure 3.4. following.

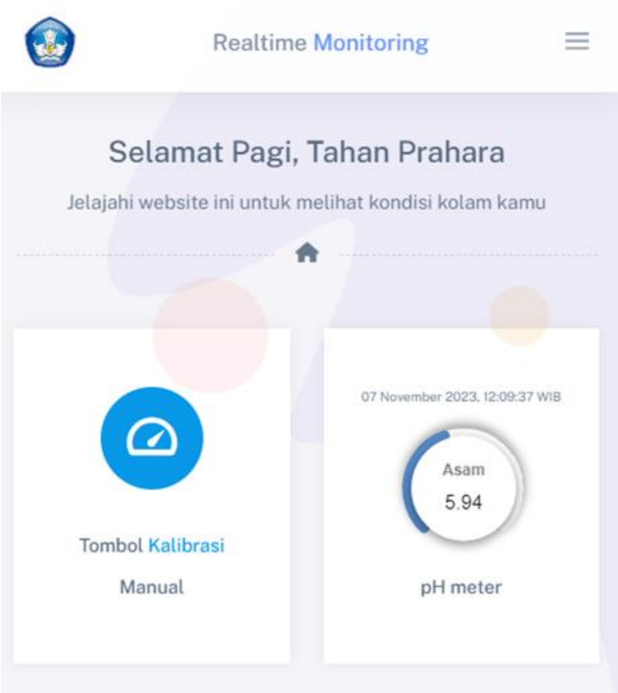

Figure 3.4. pH value display

In figure 3.4. It was shown that the pH of the pool water was 5.94 on November 7 2023 at 12.09 WIB. This shows that the water quality is good and is still ideally within the permitted value range. If the pH value is 5, then it is necessary to add dolomite powdered lime. The pH value of 5.94 is caused by ammonia and will increase if the amount of biofloc has worked to decompose ammonia into nitrites and nitrates. still ideal within the allowable value range. If the pH value is 5, it is necessary to add dolomite powdered lime.

The greatest success in IoT implementation lies in the ability to automate the control of water quality parameters. The system automatically identifies significant changes in temperature, pH, or oxygen levels, and responds by making adjustments as needed. This reduces the risk of fish stress due to environmental fluctuations and helps maintain ideal environmental conditions. Other measurement results are temperature and turbidity, shown in figure 3.5. following

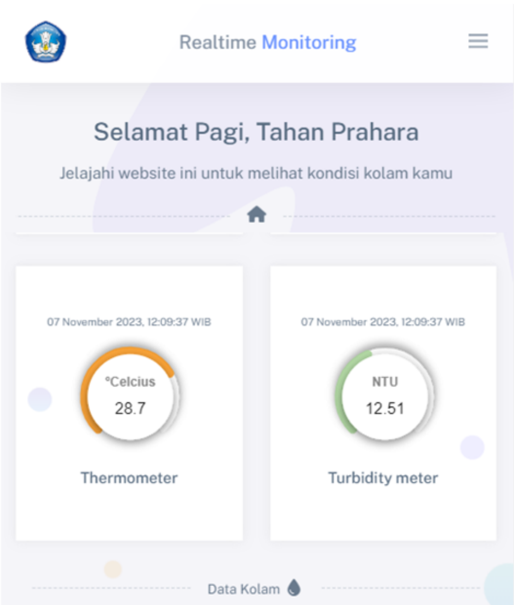

Figure 3.5. Display temperature and turbidity

Measurement results in figure 3.5. shows that the temperature value is 28,7 degrees Celsius. This value is the ideal value because it is in the temperature range of 25-32 degrees Celsius, this condition is very good for the growth of tilapia fish.

While the turbidity value shows a value of 12.51 NTU (Nephelometric Turbidity Unit) which is the standard for measuring turbidity, with the allowable value being 5 to 25 NTU. In cultivating tilapia with this biofloc system, turbidity is used to see the amount of biofloc by comparing the measurement results with a measuring cup with a capacity of 100 ml as shown in Figure 3.6 below.

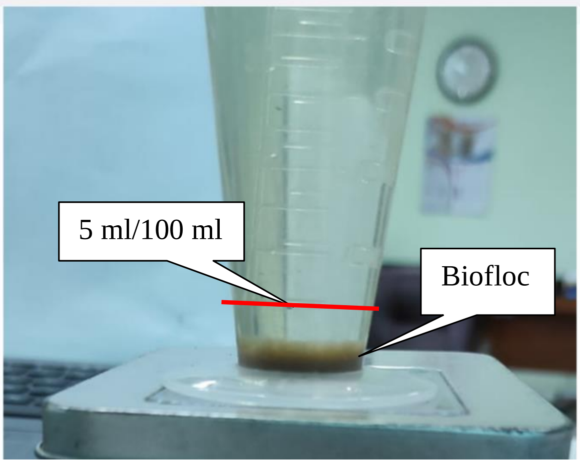

Figure 3.6. Measuring the number of flocks

The ideal floc number is 20 ml per 1000 ml water sample. The measurement results show a value of around 2 ml per 100 ml, this value if a 1000 ml capacity glass is used, the amount of biofloc obtained is around 20 ml per 1000 ml of pool water sampled. This condition is very good, meaning the floc grows perfectly and is able to decompose food waste and fish waste.

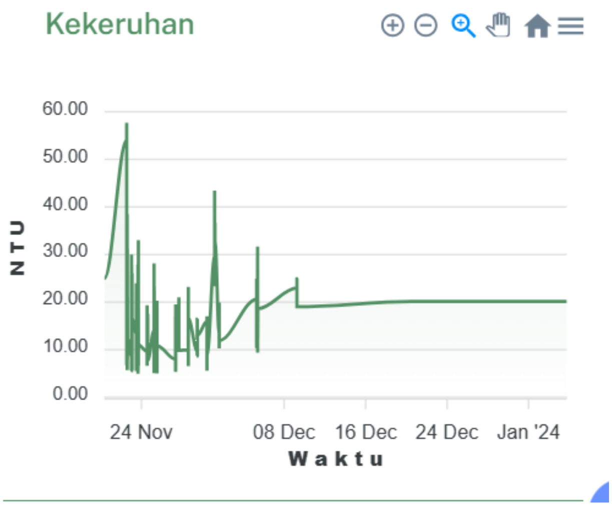

Figure 3.7. Turbidity grafic

Based on the figure 3.7, it can be seen that there were fluctuations in turbidity values from November to early December 2023, with turbidity values ranging from 10 to 20. The conditions at that time were quite heavy rain so that the pool had quite a lot of rainwater. Because the pond is made with drainage from the bottom of the pond while the rainwater is clear water, this condition is quite normal. But after December 8 2023, there was almost no rain, so turbidity increased and stabilized at a value of 20 NTU. When combined with measuring the number of flocs using a 100 ml measuring cup, a stable number of flocs is obtained at around 2 ml per 100 ml or 20 ml per 1000 ml. This condition is an ideal condition, meaning that the number of flocs is able to break down fish waste and remaining fish food. Visually observe the water color is slightly clear brown and has no smell and the fish have a very good appetite. Feeding 250 grams (1/4 kg) is completely eaten without any leftovers. If the number of floc exceeds 20 ml per 1000 ml, these conditions are not ideal, meaning that the floc will reduce the amount of dissolved oxygen in the water, thus disrupting the oxygen needs of the fish. This can cause the fish to have less appetite, which results in poor growth of tilapia.
The optimal water pH for tilapia habitat is between 6.5 – 8.5. The recommended maximum water turbidity is 50 NTU (Sunarso, 2008).

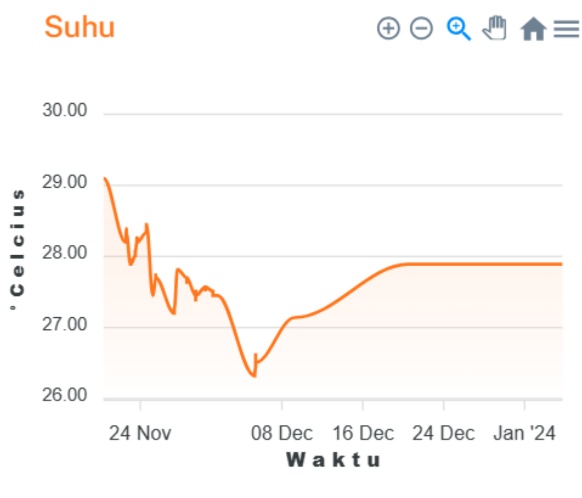

Figure 3.8. Temperature grafic

Figure 3.8. shows the temperature graph for November to December 2023. It can be seen that the temperature in December is stable at 28 degrees Celsius.

Based on research conducted by Supriyanto et al., (2019) in In tilapia cultivation there are several aspects that need to be considered, one of the reasons to suppress pathogens and diseases that infect tilapia and optimize biofloc system. Aspects that need to be considered in cultivating tilapia are: oxygen levels, PH, temperature, and water quality. According to Azhari & Tomasoa's explanation, (2018) the suitable temperature for cultivating tilapia in the biofloc system is located in the range 25^0C – 32^0C.

Yumna Cahyanti (2022), temperature is an important factor in the survival of Tilapia (Oreochromis niloticus) so attention must be paid to its maintenance in order to produce Tilapia with good productivity (Mulqan et al., 2017). The higher the temperature in water, the lower the solubility of oxygen and the higher the toxic power. The increase in tilapia pond water temperature during the day is influenced by environmental conditions, weather and wind (Pramleonita et al., 2018). This temperature affects many aspects of the life of Tilapia fish. Namely the influence of temperature on various survival, structural, physiological and anatomical aspects of Tilapia. First, this temperature greatly affects the survival of Tilapia fish (Oreochromis niloticus). Fish survival can be defined as the opportunity to live at a certain time (Fransisca & Firman, 2021). Arifin's research (2016) stated that fish can live optimally in the normal temperature range, but can also experience death (lethal) at temperatures that are too low or too high, which can disrupt their survival. This is supported by the opinion (Sucipto and Prihartono in Arifin, 2016) that water temperature greatly influences fish life, where lethal temperatures range between 10-11ºC for several days, and temperatures above the threshold can also kill Tilapia.

Second, the appetite of Tilapia fish is also influenced by the temperature in the surrounding environment. Sangwan et al. (2019) stated that Tilapia fish (Oreochromis niloticus) kept at low temperatures and high temperatures did not respond when given food. This is in line with the opinion of (Siegers et al., 2019; Arifin, 2016) which states that the optimum temperature for cultivated fish is 28-32°C, and below a temperature of 25°C, fish movement activity begins to decrease, then at high temperatures Tilapia's appetite decreases. Based on the theory, this occurs due to a decrease in the body's physiological response and a decrease in the body's metabolic rate, causing a decrease in appetite in Tilapia.

Third, this temperature also affects the body's level of stability and the level of susceptibility to disease. According to Arifin (2016), temperatures below 21ºC will facilitate disease attacks in Tilapia. This is in accordance with the statement by Azhari & Tamasoa (2018) that the metabolic processes that occur in the fish body, which play an important role in productivity and survival, are influenced by various physical factors of water quality, including temperature. Low metabolism in the body will cause the body's immunity to decrease making it susceptible to disease.
Increasing water temperature causes an increase in the immune response in fish. One that plays a role in the body's immune response is leukocytes. Leukocytes are the most active unit of the body's defense system and circulate in the blood circulation in various types. The main function of leukocytes is to destroy infectious and toxic materials through the process of phagocytosis by forming antibodies (Lubis et al., 2016). If at low temperatures Tilapia fish are susceptible to disease then this is because the number of leukocytes is unstable (less or exceeding the normal threshold). Temperature can also influence the movement of fish, this is in accordance with research results (Sangwan et al., 2019; Siegers et al., 2019) which state that at low temperatures fish swim at slow speeds and are always in the corner of the experimental tank, whereas at high temperatures the high fish swimming speed is equal to 0 cm/s or there is no movement. Then, if seen at normal temperatures, the fish move actively and swim here and there. This temperature also affects viscosity and blood flow in fish. Cold temperatures will affect the body temperature and blood temperature of the fish. The colder the blood temperature, the blood viscosity level will thicken and result in slower blood flow. A decrease in temperature has an impact on decreasing oxygen consumption and decreasing metabolic products which can be toxic, such as in the form of CO_2 gas or ammonia in the form of NH_3, whereas at normal temperatures this occurs optimally (Yustiati et al., 2017).

Figure 3.9. pH grafic

Figure 3.9. shows the pH graph for November to December 2023. It can be seen that the pH value in the 2nd week of December is stable at a value below 8.

pH quality is very necessary in the quality of fish farming water because water that has a high pH level has an effect on increasing ammonia which is toxic to aquatic living creatures, while a low pH value makes it easier for metal particles to quickly dissolve in water and has toxic properties to aquatic organisms. The optimal water pH for tilapia habitat is between 6.5 – 8.5. The recommended maximum water turbidity is 50 NTU (Sunarso, 2008).

Through continuous monitoring, IoT systems help in organic waste management in biofloc systems. This success is reflected in ammonia and nitrite concentrations remaining within tolerable limits. Better control of biofloc parameters reduces the risk of waste buildup and maintains water quality in optimal conditions.

Thus, it can be concluded that the successful implementation of IoT in tilapia cultivation with a biofloc system makes a significant contribution to operational efficiency. The ability to monitor, control and respond automatically to environmental conditions and fish needs has created a system that is more efficient, sustainable and supports optimal growth of tilapia.

Feed Consumption:
Measurements of tilapia feed consumption were also recorded, and the results showed that an automated feeding system based on monitoring fish thirst levels could optimize feeding patterns. This provides efficiency in feed use and reduces potential waste.

Biofloc Efficiency:
Measurements of the success of the biofloc system show that ammonia and nitrite concentrations remain within tolerable limits, and the system effectively manages organic waste from fish. This system, supported by IoT, allows better control of biofloc parameters, reducing the risk of waste buildup and water quality degradation.
The role of biofloc is to maintain water quality by reducing ammonia levels, while the role of IoT is to monitor water quality and display it on a web page in real time

Figure 3.10. Feed data provided

For satisfactory tilapia harvests, the most suitable feed for growing tilapia is manufactured feed in pellet form. The best feed protein content for growing tilapia is 20-30%. The amount of feed that needs to be stocked every day is 3% of the total weight of the tilapia. The total feed is divided to be distributed 2 times a day, namely in the morning (08.00), and in the afternoon (16.00).


Figure 3.11. Type of feed given

To calculate the amount of feed needed, farmers need to sample the weight of the fish every 2 weeks. The goal is that the amount of feed can be adjusted to the size of the fish, so that growth is more optimal. Here's how to calculate the tilapia fish feed needed!

How to calculate the amount of tilapia fish feed using the following formula**:**

Amount of feed per day = Fish weight x 3%.

The amount of fish feed that has been given from September to December 2023 is 20 kg with 8 strands of kale.

When the fish were introduced on early September 2023, the average weight was 65 grams per fish with a total of 50 fish. After being kept for 4 months, random sampling was carried out to obtain the largest fish weighing 500 grams, and the smallest 350 grams. The fish feed given per day is 250 grams, so the total fish weight is estimated to be around 8.6 kg. Shown in figure 3.8. following


Figure 3.12. Fish samples

Based on Figure 3.12, it can be seen that the tilapia fish look healthy and are quite fat, one tilapia fish weighs 500 grams, which when put into the pond weighs 60 grams, this shows that its feed needs can be met.
At the beginning of cultivation, 2 types of fish with different weights were used. The first type of fish weighs 23 grams and the second type of fish weighs 65 grams. after cultivating for 4 months (September 2023 to December 2023) fish weighing 23 grams will become 170 grams, while those weighing 65 grams will become 500 grams.
This research could not be carried out 100% because there was an incident that for 3 days the fish did not appear at all (like they disappeared) and after the 4th day the fish were there again in a reduced number than before. Therefore it is very important to pay attention to environmental safety

Apart from that, it also shows that oxygen needs, water pH needs and ammonia levels can be met by biofloc which can play a very good role in maintaining water quality.

4. Conclusion

Through this research, we succeeded in showing that the application of IoT in monitoring the water quality of biofloc tilapia ponds can work well, water quality measurement data can be displayed quickly and at that time. This condition is useful in maintaining water quality and the fish pond environment is always maintained in ideal conditions.
This has an effect on:

1. Increasing operational efficiency,
2. reduce the risk of crop failure due to water quality problems, and ensure fish welfare.
3. Since the pool water was first filled in August 2023 until December 2023, the water has never been changed, but the water has been filled if evaporation occurs, and the water has been drained if the pool gets rainwater. The water is brown but not foamy and odorless, this indicates that the water quality is good and the biofloc functions perfectly to break down fish waste.
4. Tilapia cultivation using the biofloc system is proven to not require large areas of land, saves water and saves electricity because it does not require a circulation pump, but only requires around 25 watts of power for the aerator.
5. The factors that most influence water quality are pH, temperature and DO. When the pH falls below 5 the pond water starts to foam, this indicates that the biofloc is unhealthy and dead. Meanwhile, when the electricity went out (not for long), the tilapia fish still survived for less than 1 hour and the pool water remained normal

By adopting this technology, it is hoped that fish farmers can increase the productivity and sustainability of their cultivation businesses, as well as make a positive contribution to the growth of the fishing industry as a whole.

Reference

[1] dkp.kulonprogokab.go.id, 2020, Budidaya Ikan Nila Menggunakan Sistem Bioflok, https://dkp.kulonprogokab.go.id/detil/201/budidaya-ikan-nila-menggunakan-sistem-bioflok, tanggal akses 24 Februari 2023.

[2] Estu Nugroho, (2021) "Budidaya Ikan Sistem Bioflok: Model Urban Fisheries Untuk Dki Jakarta", Peneliti Pusat Riset Perikanan Badan Riset Dan SDM Kelautan Dan Perikanan Kementerian Kelautan dan Perikanan, https://kkp.go.id/brsdm/pusriskan/artikel/35337-budidaya-ikan-sistem-bioflok-model-urban-fisheries-untuk-dki-jakarta, akses 23 Februari 2023.

[3] Fransiska Maharani Suryaningrum, 2014, Aplikasi Teknologi Bioflok pada Pemeliharaan Benih Ikan Nila (Oreochromisniloticus), Jurnal Manajemen Perikanan dan Kelautan Vol. 1 No. 1, Jakarta.

[4] Hari Maghfiroh, dkk (2021), Prototipe Automatic Feeder dengan Monitoring IoT untuk Perikanan Bioflok Lele, Electrician Jurnal Rekayasa dan Teknologi Elektro, Universitas Sebelas Maret, Surakarta.

[5] Ilham Firman Ashari, dkk, 2022, Sistem Monitoring dan Kontrol Budidaya Ikan Nila Berbasis IoT dengan Bioflok (Studi kasus: Kelompok Budidaya Ikan Sadewa Mandiri, Pringsewu), Suluah Bendang: Jurnal Ilmiah Pengabdian Kepada Masyarakat, Vol.22, No.2, Universitas Negeri Padang, Padang

[6] Iskandar Putra, dkk, 2022, Performa Pertumbuhan Ikan Nila Merah, Oreochromis Niloticus Pada Sistem Bioflok Dengan Frekuensi Pemberian Pakan Yang Berbeda, Jurnal Riset Akuakultur, 17 (1), 2022, 15-21, Pakanbaru.

[7] Mohamad Syaipul Anwar, dkk (2022), Perancangan Aplikasi Monitoring Kualitas Air Pada Budidaya Ikan Nila Berbasis Iot Menggunakan Android Studio, Jurnal Power Elektronik, Vol.11, No.2, Universitas Singaperbangsa Karawang.

[8] Nursobah, dkk, 2022, Prototype Sistem Telemetri Suhu Dan Ph Air Kolam Budidaya Ikan Air Tawar (Ikan Nila) Berbasis Internet Of Things(Iot), SebatikVol. 26, No. 2, Samarinda

[9] Parman Sukarno, dkk, 2022, Pemanfaatan dan Uji Kelayakan Teknologi Internet of Things (IoT) untuk Budidaya Ternak Lele dan Tanaman Kangkung untuk Mendukung Ketahanan Pangan Masyarakat Kelurahan Margasari Kota Bandung di Era Pandemik COVID19, Jurnal Pemanfaatan Teknologi untuk Masyarakat (JAPATUM)Vol. 1, Issue. 1, hal. 19-32, Bandung

[10] Tifano Sebastian Pandu Pratama, 2021, Sistem Kontrol Dan Monitoring Kualitas Air Pada Parameter Oksigen Terlarut Dan SuhuTRANSIENT, VOL. 10, NO. 4, Jurnal Ilmiah Teknik Elektro Undip, Semarang