Design and Development of Automation System For Biofloc Fish Farming

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Abstract: ***Biofloc technology is an emerging environment friendly indoor aquaculture system that degrades organic waste by microorganisms and produces microbial flocs which are used as feed for the cultured organisms. Fish production in biofloc system is very high and hence this technology has gained increased popularity. However optimal control of the biofloc environment is necessary for obtaining a high yield. In this paper an automation system is designed for maintaining the temperature of the biofloc tank at the optimal value corresponding to the type of fish cultured. Temperature sensor has been used to measure the water temperature, which is processed by an Arduino board to control a heater immersed in the tank. An experimental set up has been developed to test the system.***

Keywords: Aquaculture; Arduino; Assimilation; Biofloc; Physicochemical; pH.

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1. Introduction

Biofloc technology were developed to improve environmental control over production in aquaculture. Such technique is based on microorganism production which plays major roles in maintenance of water quality, by the uptake of nitrogen compounds generating in microbial protein. It increasing culture feasibility by reducing feed conversion ratio and decrease of feed costs.Competition with pathogens. The aggregates (bioflocs) are a rich protein-lipid natural source of food available in 24 hours per day due to a complex interaction between organic matter, physical substrate, and large range of microorganisms. This natural productivity plays an important role in recycling nutrients and maintain the water quality.

Biofloc technology combines the removal of nutrients from water with the production of floc, which can be used by some fish and shrimp as food. Biofloc technology systems in aquaculture are based on activated-sludge wastewater treatment systems and on intensive growth of heterotrophic bacteria, which consume organic carbon and immobilize inorganic nitrogen, depending on the C/N ratio (carbon-to-nitrogen ratio). Removal of nitrogen from culture water by means of biofloc technology is regulated by the balanced addition of carbon. This transformation is achieved by adding different types of organic carbon and results in the production of microbial protein that can be used as fish food.

When carbon and nitrogen are balanced in the water and microbial assimilation of the ammonia is engineered efficiently, complete retention can be obtained. Bioflocs have the potential to be used as fish food with good nutrition quality. Biofloc technology can stimulate microbial development in biofloc tanks that will lead to improved nutrient efficiency and reduced need for dietary fishmeal and fish oil. Biofloc technology can improve the efficiency of nutrients from feed. Dried biofloc can be used as a protein source in aquafeeds. Biofloc fish farming is the raising of specific species of fish in enclosures or special tanks. The objectives of this aspect of aquaculture include more than increasing the sea food supply. Investment and operating cost are the biggest obstacle in modernizing fish ponds an otherwise very lucrative industry. Small-scale farmer running a small ponds could not afford to hire workers to man daily operations which usually consist of monitoring water level, temperature and feeding fish. Biofloc systems work best with species that are able to derive some nutritional benefit from the direct consumption of floc. Biofloc systems are most suitable for species that can tolerate high solids concentration in water and are generally tolerant of poor water quality. Species such as shrimp, tuna, prawns, salman fish, cod fish and tilapia have physiological adaptations that allow them to consume biofloc and digest microbial protein, thereby taking advantage of biofloc as a food resource.

In the primary stage,first the fish are feed and cultivate in a clean water and exchange water regularly till they weight around 40g and then they are release in to the biofloc tanks or ponds. Small fishes are even cultured in biofloc system starting from 1g of the weight of the fishes. And a proper control of these parameter should be taken because this can harm the small fishesbecause of the quality of the water. And to observe a growth in these fish.

In the traditional method in biofloc system they usedto feed the fishes manually. And manually control the pH of the water by adding baking soda to increase the pH of the water, and they add molasses to decrease the pH manually. The temperature of the water tank is adjusted by adjusting the room temperature in case of indoor cultivate which is consuming more power.

2. Literature survey

The research work done by A. Sharma, R. Singh, R. Sangotra, K. Bandhana and K. Sharma [1], was on the influence of temperature on the production of biofloc. The biofloc where cultured under different environment condition namely indoor and outdoor. The experimental unit were monitor for various physicochemical parameter along with determination of biofloc volume. They found that stable floc i.e., 20-25ml/L were found at intermediate water temperature 20–25 ºC. However at high temperature i.e., 30-35ºC floc value was low due to loss of floatability and sinking of flocs at the bottom, causing more slugs formation.

According to Southern Reginal Aquaculture [2], biofloc systems were also developed to prevent the introduction of disease to a farm from incoming water. Standard operation of shrimp ponds included water exchange (typically 10%/day) as a method to control water quality. In farms practicing water exchange, disease would spread among farms. Reducing water exchange is an obvious strategy for improving farm biosecurity. Water respiration in indoor brown water biofloc systems is normally about 6 mg O_2/L per hour. Excessive solids concentration means that the response time in the event of system failure is very short, often less than 1 hour. In marine systems, maintaining a nitrate concentration of about 50 mg/L is an effective way to minimize the production of highly toxic hydrogen sulfide.

In the research work by V. Phulia, B. Mandal, A. Bera, S. K. Singh, R. Das and A. Jamwal [3], they found flocs tend to be larger and more compact at higher DO concentrations, although there is no clear relation between DO concentration and average floc diameter. At low DO levels (0.5-2.0 mg/L), flocs have poor settling properties, with a sludge volume index (SVI) of 250 mL/g and at higher DO levels (2.0-5.0mg/L) the SVI is about 100mL/g. it is found that deflocculation of activated sludge flocs occurs in cold water (4°C) than cool water (18-20 °C), probably related to decreased microbial activity within flocs (Wilen et al. 2000). At high water temperature (30-35 °C), bulking of sludge (SVI ≥ 500mL/g) occurs from excessive production of EPS (Krishna and Van Loosdrecht 1999). Flocs are stable at intermediate water temperature (20-25°C), and have an intermediate SVI (200mL/g).

The study done by Widanarni, J. Ekasari and S Maryam [4] evaluated the effect of biofloc technology (BFT) application on water quality and production performance of red tilapia different stocking densities. Three different fish densities were applied, i.e. 25, 50, and 100 fish/m3, and for each density there were Control (without external carbon input) and BFT treatments. Control treatments of each density tested showed more fluctuated water quality parameters throughout the experimental period. The highest total yield was observed in control treatment at the highest density treatment (43.50 kg), whereas the highest survival was obtained by BFT treatment at a density of 25 fish/m3 (97.78 + 0.77%). Total feed used in BFT was lower than that of control treatments in particular at 50 fish/m3 density. The application of BFT in red tilapia culture improve the water quality and fish survival as well as reduce external feed requirement. The uncontrolled reproduction process however interrupted fish growth, and eventually other production parameters of red tilapia in BFT treatments.

The objective of the study by N. Nurhatijah, Z. A. Muchlisin, M. A. Sarong and A. Supriatna [5] was to evaluate the effect of biofloc density on the water quality of the culture media of tiger prawn (Penaeus monodon). The completely randomized design method was used in this study. The experiment was conducted in three replicates and prawns were fed an experimental diet three times a day for 95 days. The results showed that biofloc density did not give the significant effect on the salinity, temperature, pH, DO, TAN and nitrite concentrations, but gave the significant effect on the nitrate and alkalinity values. In general, the range of water quality parameters are still within the standard ranges for tiger prawn cultivation in all treatments, but the several water quality parameters (i.e. TAN, nitrite ad nitrate, and alkalinity) of biofloc treatment were better than control.

The research study by H. Manan, J. H. Z. Moh, N. A. Kasan and I. Mhd [6] was on Pacific white shrimp (Penaeusvannamei), conducted in a close hatchery for days. There was no water exchange during 105 days except addition of water to refill the water level after siphoning out wastes. About 6 tanks were used, 3 for non biofloc/control and 3 for biofloc treatment. From the 3 tanks with biofloc treatment DO was recorded in range between 5.95 and 9.53 mg/L, salinity 31.60 and 36.11 ppt, pH 6.1 to 8.2, temperature 26 - 28.66 ºC, DO 83.9 – 107.4 %, TDS between 31.59 – 35.5mg/L. Nutrients level include ammonia, nitrite, and nitrate were in good condition in biofloc treatment. Biofloc microorganisms successfully work in removing the nitrogenous wasted in the treatment tanks and maintain the nutrients and water quality in the safety level for the shrimp. BFT help reduce environmental damage cause by aquaculture, reduce the use of water, and decrease feed costing as well as enabling efficient energy use.

M. G. C. Emerenciano, L. R. M. Córdova, M. M. Porchas and A. M. Baeza [7] used the a technique based on in situ microorganism production which plays three major roles: (i) maintenance of water quality, by the uptake of nitrogen compounds generating in situmicrobial protein; (ii) nutrition, increasing culture feasibility by reducing feed conversion ratio (FCR) and a decrease of feed costs; and (iii) competition with pathogens. The aggregates (bioflocs) are a rich protein-lipid natural source of food available in situ 24 hours per day due to a complex interaction between organic matter, physical substrate, and large range of microorganisms. Consumption of microorganisms in BFT reduces FCR and consequently costs in feed. Also, microbial community is able to rapidly utilize dissolved nitrogen leached from shrimp/fish faces and uneaten food and convert it into microbial protein, maintaining the water quality. The physical, chemical, and biological interactions that occur into the biofloc systems are complex; further studies can elucidate specific phenomena and their possible applications to other biotechnological fields.

3. Proposed System Design

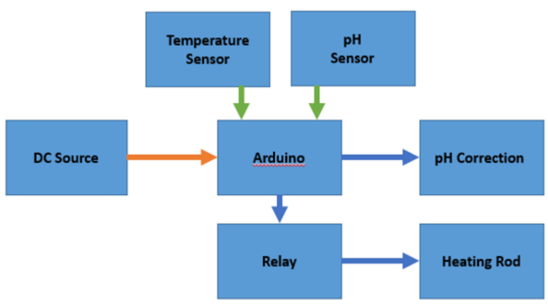

Figure 1: Block diagram of proposed automatic biofloc fish farming

Figure 1 shows the block diagram for the develop system. In this block diagram the DC source is a battery use for powering the arduino, solar is use for charging the battery. The objective here is to design automatic system power completely by renewable energy (solar). In this way the system can be install in remote place where no main AC supply is available and also for powering the whole system at night time. Here the Aduino is use as the brain of the system where it collect all the input data from temperature sensor and pH sensor (as of now). The data from the temperature sensor is converted in to Celsius and Fahrenheit, Celsius value is then use for controlling the trip command to the relay to control the temperature of the water. When the water temperature is less than the user set temperature in the program for a particular type of fish, the arduino will send a trip command to the relay to turn ON the heating rod. When the water temperature reach the particular required temperature the arduino will detect the temperature from the sensor and send the trip command to the relay to turn the heating rod off. To reduce the temperature a water pump is use to circulate a running water from separate tank of normal water through steel pipe. The water pump will start only when the temperature exceed the temperature set by the user in the programme for a particular type of fish. The water pump will also control by the same arduino through the separate relay.

The data received by the arduino from the pH sensor is in term of voltage in mV. The data is convert to pH value range from 1 to 14. The value of pH required for a particular type of fish is set by the user in the program. The value detect by the pH sensor will be compare with the user set value, if the value is found to be less than the user set value, means the water is acidic and the program will calculate and display the amount of alkaline substance need to be added in the water to bring the pH to required value. Similarly if pH value is high from the user set value, means water is alkaline and the program will calculate the amount of acidic substance need to be added to the water. The pH correction block is simply the display showing the amount of pH present in the water and showing how much value of alkaline substance or acidic substance need to be added in a particular amount of water present in a given tank capacity in order to correct the pH value according to the type of fish present in the tank.

3.1 Hardware components

3.1.1 Arduino Uno

The Arduino Uno board is a microcontroller based on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button. This contains all the required support needed for microcontroller. In this experiment the Arduino is the main component in which it collect the various data and control the different parameters.

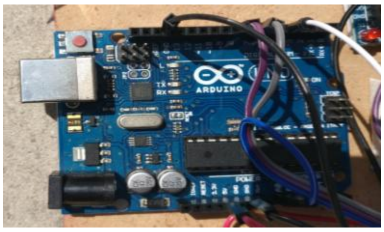

Figure 2: Arduino Uno

3.1.2 Temperature sensor (DS18B20)

The DS18B20 is a small temperature sensor with a built in 12bit ADC. It can be easily connected to an Arduino digital input. The sensor communicates over a one-wire bus and requires little in the way of additional components. The sensors have a quoted accuracy of +/-0.5 deg C in the range -10 deg C to +85 deg C. DS18B20 is use in this experiment as it is a submersible sensor which help in collecting data at various depth of the water tank.

Figure 3:DS18B20 sensor

3.1.3 pH Sensor

PH is commonly used for water measurements, it is a measure of acidity and alkalinity, or the caustic and base present in a given solution. It is generally expressed with a numeric scale ranging from 0-14. The value 7 represents neutrality. The numbers on the scale increase with increasing alkalinity, while the numbers on the scale decrease with increasing acidity. Each unit of change represents a tenfold change in acidity or alkalinity.pH sensor help to detect the pH of the water tank to determine the amount of pH that need to be correct for the particular type of fish.

Figure 4: pH Sensor

3.1.4 Heating rod

The heating rod is a 50W RS Electrical RS008-A dual protection. This make it suitable for heating. The immersion rod is a coiled rod that works as a resistor. Once an electric current is passed through the rod, its conducts heat, thus causing the surrounding area around the rod to heat up. This rod is use for increasing the water temperature in the water tanks with the help of a relay.

Figure 5: Heating rod

3.2 System operation

In this research experimentation, the Aduino is used as the controller for the system where it collect all the input data from temperature sensor and pH sensor (as of now). The data from the temperature sensor is converted in to Celsius and Fahrenheit, Celsius value is then use for controlling the trip command to the relay to control the temperature of the water.

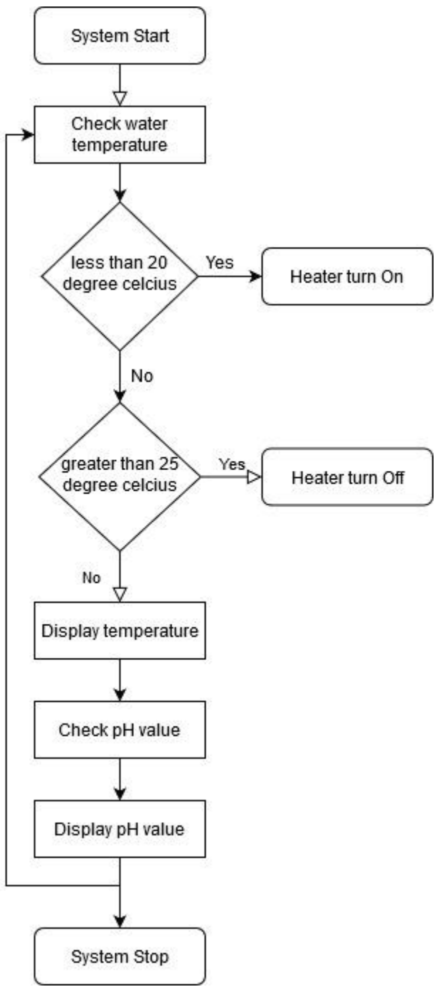

Figure 6: Flow chart of the operation

Figure 6 show the flow chart of the system on how it operates. The temperature sensor is used for detecting the water temperature and send the data to the Arduino and display the temperature value in the serial monitor.

When the water temperature is less than the user set temperature in the program for a particular type of fish, the Arduino will send a trip command to the relay to turn ON the heating rod. When the water temperature reach the particular required temperature the Arduino will detect the temperature from the sensor and send the trip command to the relay to turn the heating rod off.

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3.3 Experimental setup

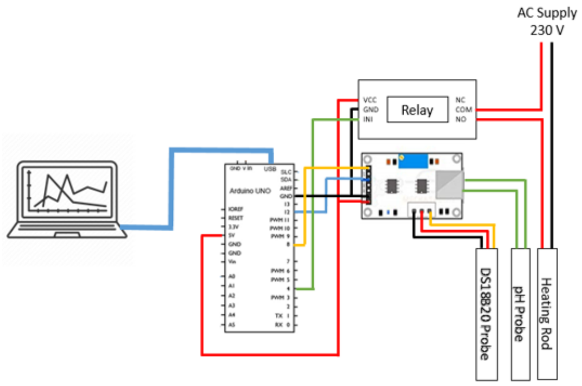

Figure 3: Circuit Diagram

In figure 3, the laptop is use for powering the Arduino and also monitoring the temperature and pH value of the solution. The laptop is connect to the arduino via USB cable. The arduino 5V is connected to the VCC of the relay and the temperature/pH module. Similarly the Ground of the arduino is connected to the Ground of relay and the temperature/pH module. It is used for powering the relay and the temperature/pH module.

Pin 4 of the arduino is connected to the relay Input pin to give trip command. The relay will operate depending on the relay trip command and it will turn ON/OFF the heating rod. The heating rod line wire is connect to the relay NO and the neutral is connect direct to main AC supply, So that the heating rod will be in OFF position and turn ON only when a trip command is given from the Arduino (i.e., when required to raise the temperature).

The pH probe is connected to the temperature/pH module via BNC connection that came along with the probe. The red wire and the black wire of the DS18B20 probe is connect to the positive terminal (red wire) and negative terminal (black wire) of the temperature/pH module, so that it can provide power to the DS18B20 probe. The yellow wire is connected to the data pin of the temperature/pH module, this will send the data from DS1820 probe to the temperature/pH module.

The temperature output data of the temperature/pH probe is connected to pin 8 of the Arduino and it will send the temperature output data to the Arduino. And the pH output dataof the temperature/pH probe is connected to pin 12 of the Arduino and it will send the pH output data to the Arduino.

Table 1: Parameter range

Sl No.	Fishes	pH	Temperature	Dissolve Oxygen
1.	Tilapia	6 – 9 pH	25 – 30 ºC	2.3mg/L
2.	Cat fish	5 – 7 pH	20 – 29 ºC	2 mg/L
3.	Salman fish	5 – 6 pH	14 – 15 ºC	2.1 – 2.5 mg/L
4.	Cod fish	6.7 pH	20 ºC	2 – 5 mg/L
5.	Tuna fish	5.2 – 6.1 pH	25 – 33 ºC	2 – 5 mg/L
6.	Prawns	7.2 – 8.8 pH	29 – 31 ºC	2 – 5 mg/L

In the above table, there are varieties of fishes and various parameters to be maintain for these fishes such as pH, temperature and dissolve oxygen. And these parameters are very important to maintain for the good growth of these fishes.

3.4 Assessment of Water Quality Parameters

The water was monitored for various parameters, water temperature, pH, DO. Water temperature was measured twice a day in the morning and evening using temperature sensor pH was monitored once daily using pH sensor.

4. Result and Discussion

The testing of the working of the components is done each separately. The first test is the relay, the test is on normally open (NO) connection, the purpose of the test is to give the trip command from the arduino to turn on the heating rod with a delay of 20 sec and turn off after 20 sec then remain off for 10 sec, then it will turn back on and repeat. This test is done to check the capability of the relay to switch On/Off in a short duration, to determine that the relay will able to trip with a given range of temperature. The test is done successfully.

The second test is the DS18B20 probe (temperature sensor), the test is done both at room temperature and in cold water. The reading from the sensor display in the serial monitor is compare with the temperature ready by digital multimeter. It is found that the temperature read by DS18B20 probe is less by 2 degree Celsius as compare to the reading of the digital multimiter in cold water and 1 degree less in room temperature. The test is done by connecting the DS18B20 probe directly to the arduino without temperature module. The temperature is calibrated in the module, thus the test is done successful.

Table 2: Temperature testing output

Time in sec	Temperature in degree Celsius	Temperature in degree Fahrenheit
1	29.62	85.32
2	29.62	85.32
3	29.69	85.44
4	29.69	85.44
5	29.62	85.32
6	29.62	85.32
7	29.69	85.44
8	29.62	85.32
9	29.62	85.32
10	29.62	85.32
11	29.69	85.44
12	29.62	85.32
13	29.69	85.44
14	29.69	85.44
15	29.69	85.44

The third test is combining by connecting both the relay and DS18B20 probe to the arduino. The test is done by setting a range of temperature (35 – 45 degree Celsius). In this test when the temperature is less than 35 degree Celsius the relay will trip and the heating rod will be turn on. When the temperature is reaching 45 degree Celsius the relay will trip and turn off the heating rod. The test is done successfully.

The fourth test is the testing of pH probe, the test is done through the temperature/pH module using BNC connection. The test is first test without DS18B20 probe, the test is done successfully with the pH value is display in the serial monitor. Then the test is done with both pH probe and DS18B20 is connected to the module. The test is successful with both the pH value and temperature reading is observed in the serial monitor.

5. Conclusion

Temperature controlled biofloc system can very effectively increase the fish yield per year, increasing the annual net profit. The automated system developed can very effectively and selectively control the tank temperature depending on the type of fish. Use of low cost components in development of the system shall make the system affordable for the fish farmers. Further automation in terms of pH control, feeding control can be incorporated in the system for complete automation.

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