

Design Innovation of Automatic Ammonia Control System for Environmentally Biofloc Fish Pools

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Abstract. Fish cultivation in tarpaulin ponds or Biofloc Technology (BFT) has been widely practiced by the community. Net fish production at BFT is 45% higher than at others. Tarpaulin ponds with a diameter of 1-2 meters (m) can be filled with 1,000-3,000 catfish seeds. The problem is that when fish farming runs for \pm 1 month, the ammonia content in the pond begins to be felt, marked by an unpleasant odor in the pond water. Excessive ammonia content can cause fish to die easily, disrupting the environment and health. The research objective is to design, manufacture, test, and implement an automatic control system for ammonia content in biofloc ponds, which will be implemented in 2022. The research method is an experimental method. The stages include: designing and making monitoring of ammonia content, designing and manufacturing an automatic water disposal system, and testing and implementing an automatic control system for ammonia content in biofloc ponds. The test results show that the automatic ammonia controller can work well. When a certain level of ammonia is detected in the pool water, the ammonia sensor is active and provides information to the microcontroller to activate the solenoid and open the drain, so that the pool water is reduced and replaced with new water. The reduction in ammonia levels is done by reducing the capacity of the pool water (the old one) and adding new water automatically and adding a water neutralizer in the form of lime.

Keywords: biofloc pool, ammonia control, automatic

1 Introduction

Fish cultivation in biofloc ponds or Biofloc Technology (BFT) has been widely practiced by the community, namely fish cultivation in tarpaulin ponds. Biofloc comes from the word bios which means life and flock which means lump, so biofloc is a collection of various types of organisms such as fungi, bacteria, algae, protozoa, worms, and others, which are incorporated in clumps. Biofloc technology or activated sludge is the adoption of biological treatment technology for activated sludge wastewater by using microorganism activity to increase carbon and nitrogen. In aquaculture ponds, biofloc technology removes toxic metabolites and helps to retain more nitrogen in the form of fish through the production of microbial mass protein [1].

Fish farming in biofloc ponds is quite effective for urban areas, especially for people who have quite a narrow land. Net fish production was 45% higher in BFT. Tarpaulin ponds with a diameter of 1-2 m can be filled with 1.000-3.000 catfish seeds. All inlet and outlet systems of BFT should be free from leakage, and to avoid carriers such as crabs and birds, preventing nets should be installed [2]. The success or failure of fish farming in biofloc ponds like this is not only influenced by feed, but also by the condition of the water as the living environment. The condition of the water as a living medium for aquatic biota must be adjusted to the optimal conditions for the biota being maintained. The water quality includes physical, chemical, and biological qualities. Physical factors such as temperature, brightness, and depth. Chemical factors include pH, DO, CO₂ and NH₃. Water temperature also affects chemical reactions and microbial growth [3]. The optimal temperature range for fish life is 28°C-32°C. While a good temperature range for tilapia cultivation is 25-30°C. In the present study, the day temperature within the ponds didn't fall below 17.86°C, and fish probably didn't stop eating[4]. Furthermore, the effect of temperature on the nursery and compensatory growth of pink shrimp *Farfantepenaeus brasiliensis* reared in a super-intensive biofloc system [5].

The problem is the temperature of the pool water is different between day and night. The temperature of the pool water during the day is hotter than at night, because during the day it is exposed to sunlight, while at night it is not, and indeed the air temperature at night tends to be cooler. Cold water temperatures cause fish farming productivity to be not optimal because water temperature greatly affects the metabolic ability of fish. In addition to water temperature, the conditions of pH, DO, CO₂ and NH₃ in ponds also need to be controlled so that they are always in accordance with the needs of fish farming. Therefore, it is necessary to research to solve these problems [6].

This research specifically aims to design a smart fish pond that is able to maintain water temperature, pH, DO, CO₂ and NH₃ in a biofloc pond automatically, which is driven by electricity from the sun (PLTS). This research is feasible because the fish farming community really needs smart ponds to increase the productivity of fish farming. In addition, research is an effort to create a new source of electrical energy that is environmentally friendly, by converting sunlight into electricity as a driving force for smart fish ponds. Smart fish pond technology already exists, but no one has yet used electricity from sunlight.

The research to be carried out is by following the research roadmap of the Politeknik Negeri Malang Integrated Applied Technology Research Center towards food security, namely Smart Farming. The Automatic Ammonia Control System will be produced as part of smart farming, namely pool technology that can automatically maintain ammonia (NH₃) levels. This is the application of technology before harvest to increase the productivity of fish farming in biofloc ponds to achieve food security for fish cultivating communities.

2 Methods

A. Working Principal

- B. In this study, an automatic ammonia control system will be designed and implemented in a biofloc pond, aiming to prevent fish from dying easily, reduce unpleasant odors, and maintain environmental health. A basic factor in designing a biofloc system is water treatment. Biofloc systems work best with species that can derive some nutritional benefit from the direct consumption of floc. At its core, biofloc is a wastewater treatment system and was developed to mitigate the introduction of diseases into agriculture facilities or farms from incoming water (water exchange, typically used in prawn farming) [7]. The design of the research tool is as shown in Figure 2.1.

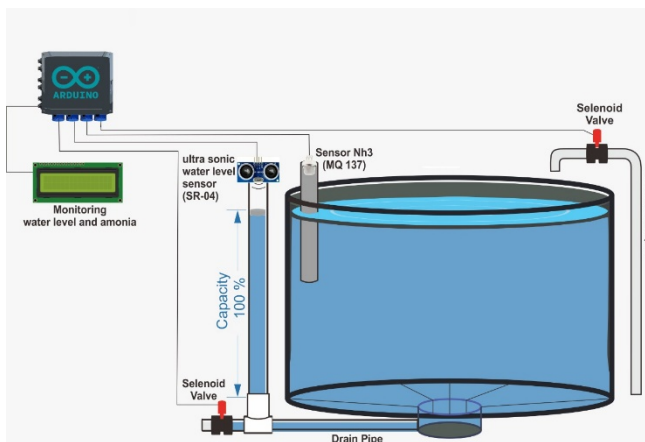


Fig. 1. Automatic ammonia control system in biofloc pond.

The working principle of the system is as follows:




1. Biofloc ponds with a diameter of 1-2 meters are filled with water as high as 50-80 centimeters (cm) from the bottom of the pond. Water capacity is measured by a water level sensor installed in the pond.
2. The biofloc pond is filled with 1000 catfish seeds measuring 5-7 cm.
3. The process of cultivating and maintaining fish from the beginning to harvesting for an average of 3 months.
4. Over time, usually when fish farming runs for ± 1 month, the ammonia content in the pond begins to be felt, marked by an unpleasant odor in the pond water.
5. The ammonia sensor (NH_3) will detect the ammonia content in the pool water.
6. Information on ammonia levels in pool water is sent to Arduino UNO.

- 7. If the ammonia level in the biofloc pool water reaches a certain number (exceeds the maximum allowable limit), the Arduino UNO will automatically instruct the solenoid valve on the drain pipe to open.
- 8. Conversely, if the ammonia level in the biofloc pool water reaches a certain number (minimum limit), the Arduino UNO will automatically instruct the solenoid valve on the water drain to close.
- 9. Dirty pool water will be wasted through the sewer and the ammonia content in pool water will be reduced.
- 10. The addition of pool water is done manually according to the amount of water removed.
- 11. Simultaneously, a water neutralizing agent is added manually, to neutralize water and reduce unpleasant odors in pool water.

C. Tools and Materials

Some of the tools and materials that must be prepared to realize the design proposal in this study are shown in Table 1, equipped with specifications for each required system component.

Table 1. Tools and materials

No.	Item	Specification	Quantity		Picture
1.	Steel bar	Dia. 8 mm	16	stalk	
2.	Tarpaulin	Blue A5 - 4x5 m	2	pcs	
3.	Water Pump	<ul style="list-style-type: none">- Inlet Dia. 1 inch.- Outlet Dia. 1 inch.- Rated voltage: AC 220V/50Hz- Peak Current: 5A-Max. Power: 1100W- Start operate current: 2A (440W)- Start operate pressure: 0.03MPa.- Flow rate: 5-7 l/min.- Max. Temp.: 80°C	2	pcs	

4.	PVC Pipe	Dia. 1 inch.	4	meters	
5.	Fitting PVC Pipe	Tee AW – Dia. 1 inch.	8	pcs	
6.	Fitting PVC Pipe	Elbow 90° – Dia. 1 inch.	8	pcs	
7.	PVC Pipe Glue	40 g	2	pcs	
8.	Solenoid Valve	220 V – Dia. 1 inch.	4	pcs	
9.	Arduino	UNO R3	2	pcs	
10.	Ultrasonic Sensor HC-SR04	Measurement range: 2 – 400 cm	2	pcs	
11.	LCD Display	16x2 Screen display – 5 DCV	2	pcs	
12.	Ammonia (NH ₃) Module Sensor	MQ-137	1	pcs	
13.	Roll Cable	2500W/10A – 3x0.75 cable size – 10 meters length	2	pcs	

In general, the sequence of the research process is depicted in the research flow chart shown in Figure 2. Where the flow chart explains the steps in carrying out research so that valid and accountable data are obtained.

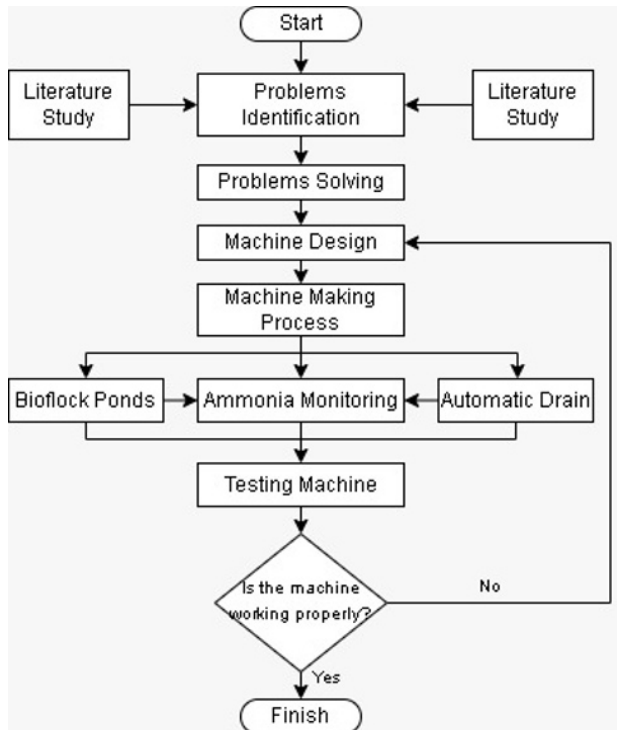


Fig. 2. Research flow chart

3 Result and Discussion

The use of cylindrical geometry in the design of biofloc ponds is considered more flexible when compared to permanent ponds made of bricks and cement. Flexibility in terms of manufacturing costs because it only uses steel bars as a frame and tarpaulin as a water container. With this model of making ponds, it is possible to disassemble and install easily and can be moved around according to certain considerations, such as the placement of clean water installations and sewerage installations.

Furthermore, the basic design of the biofloc pond is deliberately made to resemble a taper where the lowest point is right at the center of the pond's bottom diameter. This is so that the dirt from the metabolic processes of fish or soil and dust particles can be directed by itself using the force of gravity or the difference in height, where the center of the diameter of the pond has a lower position than the circumference of the pond circle.

One of the advantages of the biofloc pond design proposed in this research is the use of the Ultrasonic Water Level Sensor (SR-04) which functions to obtain the position of the pond water level in real-time. The information signal or sensor readings are then sent to the Arduino UNO control device. The Arduino UNO control device is tasked with giving instructions or commands in the form of the size of the solenoid

valve opening. So that when the pool water level decreases due to evaporation, the solenoid valve will open, and clean water will flow to the biofloc pond up to a certain water level (set point) then the solenoid valve will close again. This control system is also equipped with a 16x2 display screen LM016L for easy monitoring of water level and ammonia content. To measure the amount of ammonia content used sensor NH₃ (MQ 137). When the ammonia content reaches a certain value, the solenoid valve in the drain automatically opens so that dirty water comes out and is replaced with clean water. The schematic of the control system Arduino-Based Controller is shown in Figure 3.

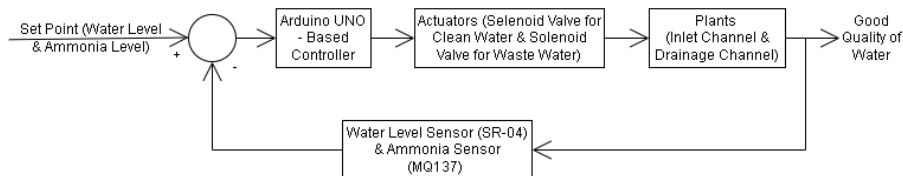


Fig. 3. Schematic Control System

The biofloc pond is designed to be 1 meter in diameter and 1 meter high. The construction of the pool is made of webbing iron, while the walls of the pool are made of special tarpaulin material for biofloc pools. The biofloc pond made in this study is shown in Figure 4.



Fig. 4. The biofloc pools

The automatic control system for ammonia content is designed using electronic components in the form of ammonia sensors, ultrasonic sensors, solenoid valves, DC relays, and LCDs as display boards. These components are assembled and installed in the electrical panel box to make it safe and look aesthetically pleasing.

On the outside of the control panel, there are 3 kinds of displays, namely the time display, the display of the condition of the pool water temperature, and the display of the ammonia content in the pool. The time display can show the day, date, month, and year in real-time. The display of pool water temperature conditions can show what the pool water temperature is in the channel before and after the heating element is installed in the pool. Heating elements are installed in the pool to keep the water temper-

ature stable. Ammonia content display shows how much ammonia content biofloc ponds in real-time.

The display of ammonia content is also equipped with a water level indicator and the condition of the intake and exhaust valves of pool water. This is to make it easier to monitor the amount of water in the pool and the ammonia content automatically.

The display conditions on the control panel are shown in Figure 5.



Fig. 5. The control panel display

The specifications of the components/equipment of the automatic ammonia content control system are as follows:

1. MQ-137 ammonia sensor
2. Ultrasonic sensor HC SR-04
3. solenoid valve inch
4. solenoid valve 1 inch
5. DC relay
6. LCD I2C display
7. Panels 40x30x20

The series of automatic control systems for ammonia content that have been made in this study are shown in Figure 6.

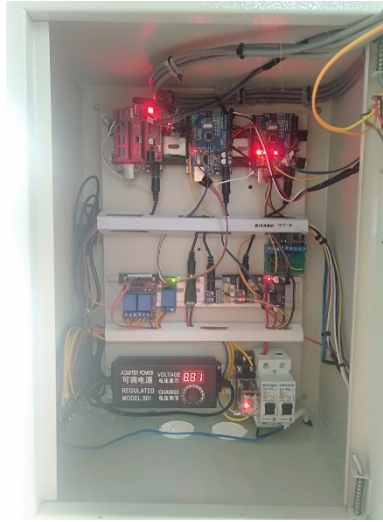


Fig. 6. Automatic control systems panel

The workings of the automatic control system for the ammonia content in the bio-floc pond as follows:

1. If an ammonia level $> 0.5\%$ is detected in the fish pond, the MQ137 sensor sends a signal to Arduino UNO to turn on relay 1 to turn on the solenoid valve (drain pipe), so that the water drains.
2. After the water is drained up to 15% of the water level is set. Then, the ultrasonic sensor will send a signal to Arduino to deactivate relay1 so that the solenoid valve (drain pipe) will automatically close so that the water stops draining.
3. After the solenoid valve (drain pipe) closes, Arduino simultaneously activates relay 2 so that the solenoid valve (clean water input) opens to fill water to the maximum limit of the pool that has been determined.

After the water is fully charged to 100%, the ultrasonic sensor will detect and send a signal to Arduino UNO to deactivate relay 2 so that the solenoid valve (clean water input) will close.

4 Conclusion

The running test results show that the automatic ammonia controller can work well. When a certain level of ammonia is detected in the pool water, the ammonia sensor is active and provides information to the microcontroller to activate the solenoid and open the drain, so that the pool water is reduced and replaced with new water. The reduction in ammonia levels is done by reducing the capacity of the pool water (the old one) and adding new water automatically and adding a water

neutralizer in the form of lime. So that biofloc pond automation and Arduino-Based Controller can increase the effectiveness of water quality to create an environmentally friendly freshwater fish cultivation. Furthermore, a good fish ecosystem can increase the productivity of freshwater fishery products and can reduce operational costs.

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