Water Quality Control for Shrimp Pond Using Adaptive Neuro Fuzzy Inference System: The First Project

F Umam1, H Budiarto2

1,2 Department of Mechatronics, University of Trunojoyo Madura, Jl. Raya Telang, Kamal, Bangkalan, Madura 69162 Indonesia

Email: faikul@trunojoyo.ac.id

Abstract. Shrimp farming becomes the main commodity of society in Madura Island East Java Indonesia. Because of Madura island has a very extreme weather, farmers have difficulty in keeping the balance of pond water. As a consequence of this condition, there are some farmers experienced losses. In this study an adaptive control system was developed using ANFIS method to control pH balance (7.5-8.5), Temperature (25-31 °C), water level (70-120 cm) and Dissolved Oxygen (4-7.5 ppm). Each parameter (pH, temperature, level and DO) is controlled separately but can work together. The output of the control system is in the form of pump activation which provides the antidote to the imbalance that occurs in pond water. The system is built with two modes at once, which are automatic mode and manual mode. The manual control interface based on android which is easy to use.

1. Introduction

Shrimp is a water commodity that has a good potency. In addition it has delicious taste, shrimp are also highly valued and give a positive contribution in the addition of foreign exchange a country. In Indonesia, shrimp farming is done by utilizing pond land. There are several things to consider in maintaining the water balance of ponds for shrimp farming to succeed properly, for example pH should range from 7.5 to 8.5, temperatures ranging from 25 to 31 °C, water level 70 cm - 120 cm, and DO (Dissolved Oxygen) 4 - 7.5 ppm [1].

Pond water quality control that focuses on pH and alkalinity equilibrium has been done using ozonation method [2]. Unfortunately in this study the control is still done manually and not yet using computerized system. In 2012, the hydrobiological monitoring system began to be developed online. In the study ponds / ponds are made in a modern way. The research focuses only on pH, DO and other pH monitoring systems performed online and realtime, while the control system for maintaining water balance has not been done [3] [4].

Research on hydrobiological balance monitoring was further developed by Daudi Simbeye et al. in 2014. The study also focuses only on monitoring systems [5]. Research on water quality monitoring and control is also done by focusing on 4 aspects at once: sensing and instrumentation, communication and networking, computational techniques, and control systems [6]. This research is very general and has not focused on pond water equilibrium system. The monitoring system of pH, DO and pond water temperature is also done by utilizing the network and done online. The final monitoring data can also be sent via SMS service [7]. In addition to monitoring systems, research on shrimp farming also leads to land searching that suits shrimp ponds. The decision-making process uses AHP to determine which land is good for brackish shrimp ponds [8].
Research on Automatic controls to adjust pH, DO, and water levels using Raspberries are already done online. Settings for maintaining pH, DO and water level are set online using an interface built using html [9]. The use of artificial intelligence methods to control pH development began. Fuzzy logic is embedded in the PLC to maintain pH balance. But in this study control only focuses on maintaining pH balance only [10]. Research on potatoes maintaining micro hydrobiologic balance is very much done [11] [12] [13]. Unfortunately, the existing research focuses only on monitoring systems, while control systems to maintain microhydrobiology have not been performed.

Therefore, in this study created a control system that works automatically to maintain the balance of pH, temperature, water level, and Dissolved Oxygen. The control system created can work adaptively in maintaining the pH balance, temperature, water level, and Dissolved Oxygen. The system is made using Raspberry PI equipped with various sensors and artificial intelligence for the system to work autonomously. Artificial intelligence is built using ANFIS method that works based on pH value, temperature, water level, and Dissolved Oxygen. This tool will be applied in a special area that the climate is very extreme, such as in Madura area of East Java Indonesia.

2. Research Object
The research object developed in the form of a tool made using Raspberries equipped with pH sensor to measure pH balance, temperature sensor to measure pond water temperature, ultrasonic sensor to measure water level and DO sensor to measure dissolved water oxygen content of pond. As in Figure 1, the four sensors are connected directly to the raspberry PI as the main controller. The measurement value of the sensor is then inputted and processed using ANFIS to determine decision making.

3. Sensors Module
   a. pH Probe Sensor to measure pH balance, power module 5V, pH Range 0-14, precision level ± 0.1 pH, response time ≤ 1 min
   b. LM35 Temperature Sensor for temperature measuring, 0.5 °C accuracy, operates from 4V - 30V, range -55 °C - 150 °C
   c. Ultrasonic Sensor for measuring water level, HC-SR04 Module, Voltage 5V DC, Current 15mA, max range 4m, min range 2 cm, Frequency 40Hz
d. Dissolved Oxygen Probe to measure water oxygen level, Range 0 - 35 mg / L, Response Time ~ 0.3 mg / L / sec, Max Pressure 100 PSI

4. ANFIS (Adaptive Neuro Fuzzy Inference System)
In this study, the calculation of pH balance value, temperature, water level and Dissolved oxygen are divided into 4 parts: pH with ΔpH produces pH, Temperature with ΔTemp produces Temperature, Level with ΔLev yields Level, and DO with ΔDO. Each case was calculated separately using the ANFIS method. Eight data will be in training offline using matlab to find the ideal Fuzzy Inference System with the smallest error.

The basic essence of data training is that FIS is generated based on data mapping and trained by varying the premise and consequent parameters, so that the resulting FIS can follow the predetermined output. The four parameters are trained for 5000 epoch each, whereas the smallest error in the pH data processing process is 0.082. Figure 2 is the output of offline training data on the pH controller. Output is the action of opening acid or base faucet in 3 membership function, ie zero (closed closed faucet), Open_Small (open faucet), and Open Big (open faucet very wide). The farthing of the output depends on the resulting pH value. If the pH value returns to normal then the faucet will automatically close.

Figure 3 is the output of offline training data on the DO controller. Output is the action of turning the windmill in 3 membership functions: zero (silver windmill), Slow (medium spinning windmill), and Fast (windmill spin fast). Fixed output also depends on the value of DO produced. If the value of DO returns to normal then the windmill rotation will be stopped.

5. Results and Discussion
The system is made using python programming language. Raspberry PI as the main controller receives data from the sensor and processes the data to produce a certain action in maintaining the quality of water. To produce a stable control, each parameter is controlled separately but can work simultaneously. In addition, in this study also made two control modes namely automatic mode and manual mode. Automatic mode is the control mode where the whole system works autonomously by relying on artificial intelligence that has been planted. While the manual mode is a mode where the control is done by the user with an android based interface that can be accessed via smartphone.
In Figure 4 (a) display the system's initial view. There are two menu options namely "Monitoring Adaptive Control" and "Manual Control". The Adaptive Controls Monitor menu will display the current state and system state such as Figure 4 (b). Users will only be informed of the pH, Temperature, Water Level and DO values and the control actions that the system is performing, because in this position, the system works autonomously using artificial intelligence already provided. Manual control As in Figure 4 (c) is a page that displays pH, Temperature, Water Level and DO values and gives the user the freedom to manually control by pressing Zero, OS (Open Small) and OB (Open Big). If the user selects the manual control menu, the automatic adaptive control stops.

Figure 5 is a user interface for adaptive control system. Based on the measurement results, the pH is in the range of 7 to 9. In theory, this indicates that there is an imbalance of pH value. Therefore the control system will automatically open the Acid faucet with Open OS level until the pH level returns to normal. If the pH level returns to normal, the Acid faucet will automatically close. Likewise with the temperature sensor readings, based on the measurement results, the water temperature ranges between 35-40 °C. In theory, the temperature of 40 °C is in the position of less good category for shrimp development. Therefore the system will automatically open the faucet with the OB (Open Big) level of drainage and replace it with new water until the normal temperature point is reached. Water level measurements using ultrasonic sensors still show at safe levels, ranging from 110-111 cm and this is a good category for shrimp farming. In this case the system will not react (Zero) because the
water level is still in a safe position. Results Measurements of DO sensors show still within safe limits ranging from 5-6 ppm.

6. Conclusion
Overall the system works very well. The measurement of the sensor is very precise and the adaptive control works well. In addition, to facilitate the fishpond management, the system can also be controlled manually using a smartphone with a very simple user interface and easy to operate even by the layman though. Based on the test results, ponds on the island of Madura, East Java Indonesia with extreme weather yang, water temperature is quite high, ranging between 35-40 °C, of course, this also affects the pH. But with the existence of this control system, the problem has been resolved well.

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