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# Survivability of Aqua Marine Products in Fish Ponds through Water Quality Evaluation Using Machine Learning Algorithm

Lester G. Loyola[1], Dr. Luisito L. Lacatan[2]
[1]Student-Doctor of Information Technology
[2]Dean – College of Engineering
AMA UNIVERSITY, Quezon City Philippines

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***Abstract:***
Water quality is considered as the most important factor in aquaculture production systems affecting fish health and performance. Water quality can be considered good if it relates to what aquaculture wants and needs to survive and develop, which means that aquacultured farmers must be able to understand the water quality requirements of their cultured products to ensure their fast growth and survival. Different species of fish have different and particular aspects of water quality needs in which they can live, grow and reproduce.[1]–[5] It is, therefore, imperative for fish producers to make sure that the physical and chemical conditions of pond water remain, as much as possible, within the optimum or acceptable range of the fish under culture all the time. Fish may show poor development, erratic behavior, and signs of disease or parasite infestations outside of these acceptable ranges. Fish kill can occur in extreme cases or where poor conditions persist for extended periods of time.[1], [4], [6]–[8] Using water sampling to monitor water quality takes up time, while laboratory results do not show the current state of water in fish ponds, which is critical information needed by fish farmers. Water quality monitoring in fish ponds should be in real-time, analysis of water parameters must be done as soon as possible to ensure water quality and its acceptability for aquacultured products. The purpose of this study is to develop a system that can monitor water parameters in fish ponds analyze and evaluate these parameters to determine the suitability and survivability rate of aquacultured products base on water quality using machine learning algorithms regression tree and decision tree in accordance with the water quality requirements of cultured products. With the help of Arduino microcontroller device that uses IoT (Internet of Things) technology. By implementing this study, it was found out that the system effectively helps the fish farmers to manage and help maintain the water quality of their fish ponds it minimizes losses due to untimely solutions to water quality problems and promotes a healthy environment which helps increase the growth and survival of aquacultured products. It also increases the fish farmer harvest and income, which creates a positive impact on agricultural productivity in terms of fish farming.

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## I. Introduction

Fish farming is a method of raising aquacultured products in fish ponds, customized tanks or net enclosures in rivers or sea water. The main objective is to cultivate and grow fish or other aqua culture products in a shorter period of time in a economically way as possible to an acceptable harvestable size. Some of the factors that farmers would be able to control to influence growth and development rate of cultured fish includes the fish pond structure and environment, food type and volume intake, water quality, and growth period.[9], [10]

The boost in fish production is significantly dependent on the chemical content and biological qualities of water, which should match the aquacultured water quality requirements. Hence, successful fish pond management requires knowledge and understanding of water quality. [11] This paper will focuses on the development of a system that is able monitor water parameters in fish ponds in real time, analyze and evaluate these parameters to determine the suitability and survivability rate of aquacultured products base on water quality using machine learning algorithms under the water quality requirements of cultured products.

## II. Methods and Procedure

This study was accomplished by following the phases in the traditional waterfall model of the system development life cycle shown in figure 1.

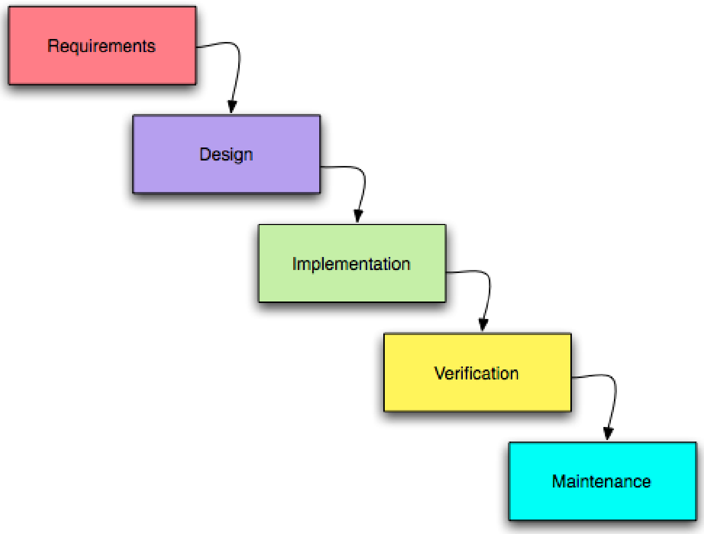


**Figure 1: Traditional Waterfall Model of SCDLC**

This research focused on the development of a system that can monitor water parameters in fish ponds, analyze and evaluate these parameters to determine the suitability and survivability rate of aquacultured products base on water quality using machine learning algorithms like a decision tree and regression tree. With the help of the local government office Bureau of Fisheries and Aquatic Resources BFAR, the researcher was able to obtain the water parameters needed in this study as well as the aquaculture range of tolerance, which includes the best water parameter for tilapia, milkfish, and shrimp. Parameters that ware obtains through personal interviews and survey questionnaires, which significantly affect survivability, health and growth of the above-mentioned aquacultures are Dissolve Oxygen, Total Dissolve Solid, PH, Temperature, Salinity and Ammonia these parameters were also verified and validated through other research .[4], [6], [8], [12], [13] This information was used in formulating the recommender system. This study is composed of hardware and software.

*A. Hardware Design of the Study*

The hardware component of this study was used to monitor the water parameter, which includes water Dissolve Oxygen, Total Dissolve Solid, PH value, and Temperature using the developed microcontroller with its sensors. Salinity and Ammonia are also monitored, but not using a sensor. These parameters are calculated and derived using the data obtained from other settings. [14], [15],[16],[17] The devices that were used in this study are listed below.

1. Arduino Dissolved Oxygen Sensor
2. Arduino Analog TDS Sensor
3. PH Meter Sensor Analog Kit
4. DFRobot DS18B20 Full Waterproof Temperature Sensor for Arduino
5. NodeMCU V3 ESP8266 Development Board CH340
6. 1602 16x2 LCD with I2C Adapter
7. Rechargeable Battery 9Volts
8. DC-DC 9V/12V to 5Volts Step Down Power Charger Bank Board
9. 3W 9V Mini Polycrystalline Solar Panel

Using the above mention devices, the microcontroller was designed using Fritzing. Fritzing is an open-source software used for documenting circuit prototypes.[18] The researcher created the microcontroller using the designed circuit shown in Figure 2. With the help of PHP scripting language and MySQL database, this microcontroller was used to gather and store water parameter information in the online system database.

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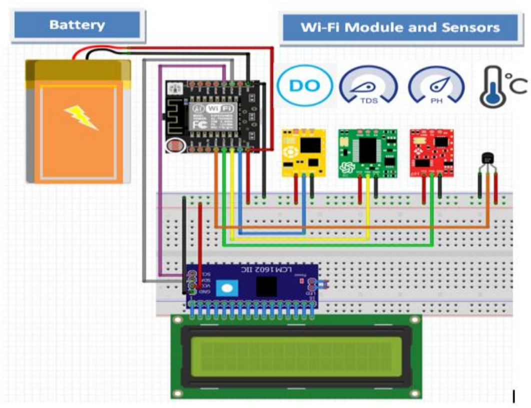


**Figure 2: Circuit Design of the Microcontroller**

Following the development of the microcontroller, the enclosure box was designed to fit the microcontroller perfectly, ensuring that it is waterproof to protect the circuit inside from potential damage. The implementation plan was later developed by the researcher shown in figure 3, with the assistance of the owner and caretaker of the fishpond the physical plan on how the system and other devices will be placed on the pond was designed and executed in consideration with the layout of the brackish pond, then later on the system was implemented.

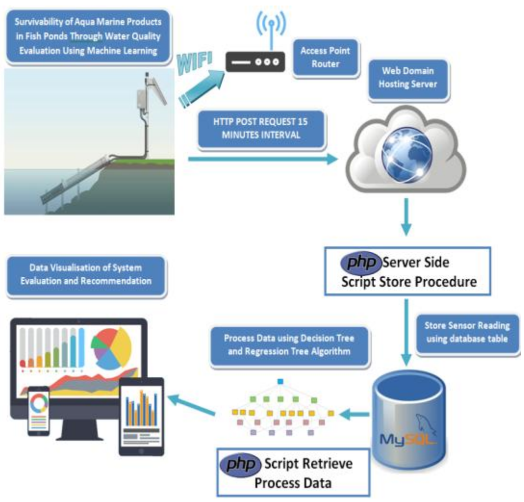


**Figure 3: Survivability of Aqua Marine Products in Fish Ponds through Water Quality Evaluation Using Machine Learning Algorithm: Implementation Plan**

*B. System Design of the Study*

The microcontroller was programmed to send water parameter information on the online system every fifteen minutes and using PHP server-side scripting language. These parameters are stored under a web domain in the MySQL database.

*a. Acquiring Water Salinity*

To be able to monitor and obtain water salinity, the data from water total dissolved solid was used by converting the conductivity unit of measurement from siemens per meter (S/m) to milli-siemens per centimeter (mS/cm) multiplying it by 10. Then raise the acquired conductivity (in mS/cm) to the power 1.088 then multiplying the result by 0.467. This will result to salinity in grams of salt per liter of solution.[15], [19]

$$TDS(mS/cm) = TDS(S/m) \times 10 \quad (1)$$

$$S = (ppt) = (TDS(mS/cm)^{\wedge}1.0878)\ 0.4665 \quad (2)$$

Where S = Salinity

TDS = Total Dissolve Solid

*b. Acquiring Water Total Ammonia*

Water ammonia can often alter due to the feeding of cultured fish in fishponds. This impacts aqua cultured development and survival, which is why it is essential to monitor ammonia frequently. The total ammonia can be measured in freshwater, as long as you also have the pH and temperature data. First calculate the pKa, which is the ionization constant of the ammonium ion. To calculate the pKa value the equation:

$$pKa = \frac{2729.69}{T} + 0.1105 - 0.000071T \quad (3)$$

where T = 273.16 + t°C is the temperature.

To compute for the fraction of NH3, the equation below was used:

$$NH3 = \frac{100}{1 + 10^{(pKa - pH)}} \quad (4)$$

To acquire the concentration of total ammonia also known as ammonia-N mg/L on a solution with un-ionised $NH_3$ of 68.7 mg/L at pH 7 and temperature of 25°C, the concentration of total ammonia-N can be acquire by doing the formula: total ammonia-N in (mg/L) = un-ionised ammonia as mg $NH_3$/L multiply to (14/17) and divided to (percentage of un-ionised ammonia divided to 100); Table 1 and 2 shows the Percentage of un-ionised ammonia which is used in getting the total ammonia. Example: 68.7 mg/L as $NH_3$ can be multiply to (14/17) and divided to (0.566/100) which is equal to 10,000 mg/L total ammonia-N. [14][16][20]

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**Table 1 Shows the Percentage of un-ionised ammonia according to temperatures and ph value (PH Range 6.5 to 7.5) [14][20]**

| pH | 6.5 | 6.6 | 6.7 | 6.8 | 6.9 | 7 | 7.1 | 7.2 | 7.3 | 7.4 | 7.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10°C | 0.059 | 0.074 | 0.093 | 0.117 | 0.148 | 0.186 | 0.234 | 0.294 | 0.37 | 0.465 | 0.585 |
| 12.5°C | 0.071 | 0.09 | 0.113 | 0.142 | 0.179 | 0.225 | 0.284 | 0.357 | 0.449 | 0.564 | 0.71 |
| 15°C | 0.087 | 0.109 | 0.137 | 0.172 | 0.217 | 0.273 | 0.343 | 0.432 | 0.543 | 0.683 | 0.858 |
| 17.5°C | 0.104 | 0.131 | 0.165 | 0.208 | 0.262 | 0.329 | 0.414 | 0.521 | 0.655 | 0.823 | 1.03 |
| 20°C | 0.125 | 0.158 | 0.199 | 0.25 | 0.315 | 0.396 | 0.498 | 0.626 | 0.786 | 0.988 | 1.24 |
| 22.5°C | 0.15 | 0.199 | 0.238 | 0.3 | 0.377 | 0.474 | 0.596 | 0.749 | 0.942 | 1.18 | 1.48 |
| 25°C | 0.18 | 0.226 | 0.285 | 0.358 | 0.45 | 0.566 | 0.712 | 0.895 | 1.12 | 1.41 | 1.77 |
| 27.5°C | 0.214 | 0.27 | 0.339 | 0.427 | 0.536 | 0.674 | 0.848 | 1.06 | 1.34 | 1.68 | 2.1 |
| 30°C | 0.255 | 0.32 | 0.403 | 0.507 | 0.637 | 0.801 | 1.01 | 1.26 | 1.58 | 1.99 | 2.49 |

**Table 2 Shows the Percentage of un-ionised ammonia according to temperatures and ph value (PH Range 7.6 to 8.5) [14][20]**

| pH | 7.6 | 7.7 | 7.8 | 7.9 | 8 | 8.1 | 8.2 | 8.3 | 8.4 | 8.5 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10°C | 0.735 | 0.924 | 1.16 | 1.46 | 1.83 | 2.29 | 2.86 | 3.58 | 4.46 | 5.56 |
| 12.5°C | 0.892 | 1.12 | 1.41 | 1.76 | 2.21 | 2.77 | 3.46 | 4.31 | 5.37 | 6.67 |
| 15°C | 1.08 | 1.35 | 1.7 | 2.13 | 2.66 | 3.33 | 4.16 | 5.18 | 6.43 | 7.96 |
| 17.5°C | 1.3 | 1.63 | 2.04 | 2.56 | 3.2 | 3.99 | 4.97 | 6.18 | 7.66 | 9.45 |
| 20°C | 1.56 | 1.95 | 2.45 | 3.06 | 3.82 | 4.76 | 5.92 | 7.34 | 9.07 | 11.2 |
| 22.5°C | 1.86 | 2.33 | 2.92 | 3.65 | 4.55 | 5.66 | 7.02 | 8.68 | 10.7 | 13.1 |
| 25°C | 2.22 | 2.78 | 3.47 | 4.33 | 5.39 | 6.69 | 8.28 | 10.2 | 12.5 | 15.3 |
| 27.5°C | 2.63 | 3.29 | 4.11 | 5.12 | 6.36 | 7.87 | 9.72 | 11.9 | 14.6 | 17.7 |
| 30°C | 3.11 | 3.89 | 4.85 | 6.02 | 7.47 | 9.22 | 11.3 | 13.9 | 16.9 | 20.3 |

### *C. Water Quality Index for Aqua Culture in Fish Ponds*

#### *a. Tilapia Water Quality Index*

Water quality requirements for aqua culture like tilapia, milkfish and shrimp came from the BFAR office and were validated using previews related researches. [5], [21]–[26]

*Ammonia*

High ammonia can be tolerated by tilapia. But an increase level of ammonia raises tilapia stress.

**Table 5. Water Ammonia Range requirement for Tilapia**

| Water Ammonia | Possible outcome on cultured Tilapia |
|---|---|
| Above 0.07 mg/L | Fish experience stress in feeding |
| Equal or above 0.2 mg/L | Few fish kill may occurs |
| Equal or above 1 mg/L | Frequent fish kill can be observe in the pond |
| Equal or above 2 mg/L | Massive fish kill can be observe |

*Dissolved Oxygen (DO)*

Tilapia is able to withstand dissolved oxygen index <0.3 mg/L. This index is known and proven deadly to majority of aquaculture. Even though tilapia can withstand low level of oxygen, it is preferable to maintain the oxygen level above 4 mg / L. In high-density cultivation situations other most fish farmer consider adding paddle wheels or pumps for emergency aeration.[27]

*Water PH Level*

Tilapia can grow and develop in PH level ranging from 5 to 10. While the best preferred pH level is in between 6 to 9.

*Salinity*

The salinity tolerance and growth requirements for Tilapia are shown in table 3.

**Table 3. Salinity Tolerance for Growth of Tilapia**

| Type | Tilapia Salinity Tolerance |
|---|---|
| Nile Tilapia | Develop well at salinities above 14 ppt |
| Blue Tilapia | Develop well at salinities above 19 ppt |

*Temperature*

Tilapia lives in warm water and is fatal if exposed to temperatures below 52 ° F. Some tilapia

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can tolerate temperatures up to 48 ° F. This limits the opportunity for commercial farming in warm regions.

**Table 4. Water Temperature Range Requirement for Tilapia**

| Tilapia Activity | Temperature Range |
|---|---|
| Food taking | Stops below (17°C) |
| Harvesting | Stress and death from handling increases if below (18°C) |
| Reproduction | Optimal at above (27°C), Stop reproduction at range below (20°C) |
| Growth | Best at (27°C-30°C) |

The online system then compares and processes the live data being sent into the database to come up with a recommendation to the fishpond owner/care taker.

*b. Shrimp Water Quality Index*

*Ammonia*

Studies showed that 0.45 mg $NH_3$ -N/1liter ammonia exposure would decrease shrimp development by 50%.

*Dissolved Oxygen (DO)*

Maintaining appropriate levels of dissolved oxygen in water from the pond is essential for the development and survival of shrimps. Prolonged exposure to low oxygen stress reduces their disease resistance and inhibits their growth. Oxygen depletion has often led to shrimp mass mortality (anoxia) in most instances. [24]–[26]

*pH Value*

Water with a pH of 7.5 to 9.0 is usually considered appropriate for the manufacturing of shrimps. Shrimp development is delayed if pH drops below 5.0. Excessive alkaline water (pH > 9.5) may also be detrimental to the growth and survival of shrimps. [24]–[26]

*Salinity*

Shrimps are able to tolerate salinity from as low as 5 ppt to a high of 40 ppt it does not have many effects in its development and growth but due to high evaporation rate in some countries like the Philippines, salt concentration in ponds gradually increases during the summer months because of this salinity may increase to beyond 40 ppt and thus retard growth.[24]–[26]

*Temperature*

Shrimp can survive on temperature from 24C˚ - 33C˚. Temperature generally improves the rate of growth of shrimp, but mortality rises at the higher temperature shown in table 5. While each species has its optimum temperature range, temperatures ranging from 26 to 30 ° C are usually regarded best for shrimp. [11], [28][29]

**Table 5. Penaeus monodo (Shrimp) Survival Temperature Index[30]**

| | | | | | |
|---|---|---|---|---|---|
| Temperature °C | 26.5 | 30 | 35 | 37.5 | 40 |
| Percent survival | 100 | 100 | 100 | 60 | 0 |

After acquiring all the water parameter data needed for the study, including optimum range of water quality for Tilapia, Milkfish and Shrimp, [5], [9], [22], [24], [25], [31] information were used in developing the water quality evaluation including the quality suitability of each aquaculture using regression both decision Tree.

*c. Decision Tree*

Decision trees are considered as supervised learning classification approach in Machine Learning. A decision tree can be used in creating a decision support system that uses tree-like graph decisions which can be answered by yes or no containing the possible after-effects or results base in the course of action.[32], [33]

Decision trees are effective instruments that can be used in several fields of Information Technology, such as data mining, text mining, information retrieval or extraction, machine learning, and pattern reorganization.[33]

In this study, each water parameter was treated as an independent variable, and a decision tree was developed for each parameter using a cause and effect approach, as shown in figure 4. Live data that enters the system pass through these decision trees to be evaluated by the system to found out the aquaculture suitability and survivability base on the current water quality.

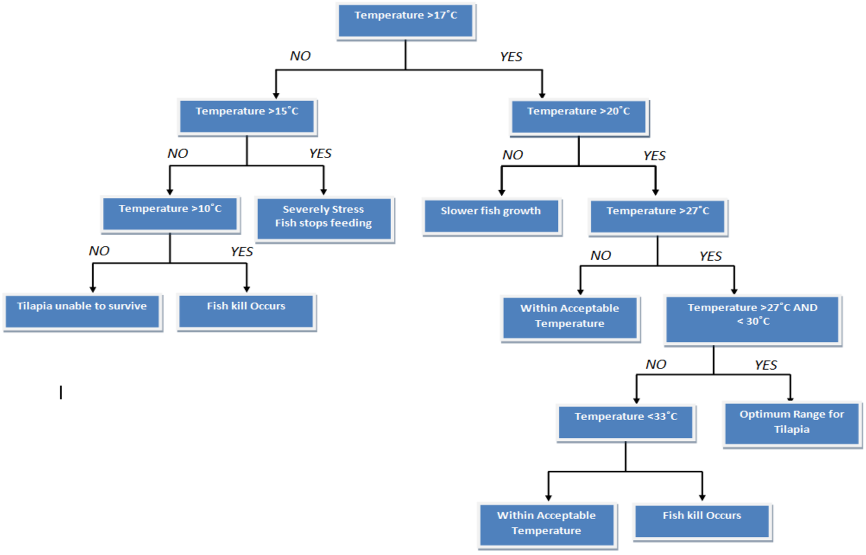


**Figure 4 System Decision Tree on the effect of Temperature on Nile Tilapia**

The system used Bootstrap, JQuery, and data tables, enabling the user to view the system using either PC or handheld devices. The system also used Google Charts to shows the water parameter on a much better and easy to understand visualization of information. The recommender system tells the current state of the fishponds and sends a warning notification through email if the current water quality negatively affects the aquaculture growth or survivability.

## III. Discussion

By implementing the system, the positive impact was observed. Information on the current water parameters help improves the water quality management of the ponds. Preparation and immediate solution to water quality problems were achieved. The online system allows the owner to view the current water state of his/her fish pond while away. Caretakers can immediately respond to the water quality problem.

Some water parameters in the fish ponds have been able to reach optimum range like dissolve oxygen and salinity through water quality treatment. The exact volume of salt can now be added to maintain salinity. Expenses in the oxygen pump during night time were reduced due to real-time water parameter information given by the system, which helps the fish farmer to start or stop the pumps depending on the data provided by the system.

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