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WATER QUALITY EVALUATION SYSTEM FOR PRAWN (PENAEUS MONODON) USING IoT DEVICE AND DECISION TREE ALGORITHM

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Abstract

Each species of fish has an optimum or preferred water quality. Optimum water quality ensures aquaculture survivability, development and growth. The main objective of this research study was to develop a water quality evaluation model using decision tree algorithm for prawn penaeus monodon also know as Black Tiger Prawn which is usually cultured in Philippines brackish ponds. In this study IoT device with water sensors was use to acquire water parameter from ponds to evaluate suitability of penaeus monodon to the water quality of ponds. To accomplish the objectives of the study water parameters that affect the growth and survivability including the optimum prepared water quality for penaeus monodon was collected and validated at BFAR. This information was used to design and create a model of water quality evaluation specially made for penaeus monodon prawn for maintaining fish pond water quality. The system was tested by experts from BFAR to see if it properly gives the correct and expected output. The study recorded a mean value of 4.55 which is interpreted as "very acceptable" in user acceptance testing. During implementation the system was able to properly collect water parameter through the use of IoT device and evaluate water quality in the fish pond. During 15 days of implementation to four different ponds location in Pampanga it was found out that three out of four ponds need to improve the water quality of their ponds concerning Dissolved Oxygen and Unionized Ammonia (NH3) content, experts from BFAR recommend adding air pumps to increase Dissolved Oxygen to make it above 7mg/L which is the optimum for penaeus monodon, reduce feeding of trash fish or change to feeds to reduce Unionized Ammonia (NH3) content to promote growth and reduce mortality**.**

Keywords -- Water Quality, Penaeus Monodon, Decision Tree Algorithm, Arduino Microcontroller, Internet of Things(IoT)

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INTRODUCTION

The Philippines started culturing prawns in 1980's in 1990's the most widely cultured shrimp is penaus monodon also known as black tiger shrimp, the name came from the dark stripes that is very visible in their shell. The Philippines is one of the biggest exporter of prawn, contributing 25% of the total fish and fisheries in export on 2013, amounting to 558 million US dollar. culturing prawn can give fish farmers good income yet water quality should be maintain properly to prevent deceases which devastated the industry during the 90's and led the farmers to switch in different aquaculture.

Shrimp growth, survivability and production are extremely dependent in the water quality of the pond. Fish farmers should be given ways to monitor and assess the water quality of their fishpond in real time, to ensure that it meets the water quality requirements of the aquaculture. This will help promote better environment for aquaculture and lessen possible mortality. This could result to reduce losses and increase harvest income for fish farmer. In this study the researcher intended to develop a system that can monitor at the same time evaluate the water quality of the pond to know its suitability for cultured shrimp.

REVIEW OF LITERATURES AND STUDIES

In the study by Chen, Jinsong, it was said that Ammonia is the common cause of pollution in the aquaculture environment which should be considered as the most important parameter in water quality. Monitoring ammonia in real time can help prevent aquaculture mortality. this was also mention in the study of Michael Phillips. Especially in fish ponds as ammonia may increase because of excessive feeding.[1], [2] Studies showed that 0.46 mg NH3 -N/liter ammonia exposure can decrease shrimp development by about 50%,[3], [4] prepared unionized ammonia NH3 is less than or equal to 0.02mg/L considered as optimum range for shrimp. The acceptable range is from 0.02 up to 0.2 mg/L, stress is experience from 0.3 to 1 mg/L and growth is affected, greater than 1 mg/L will result to mortality.[5] This confirms that ammonia content NH3 must be a priority in water quality mentoring and evaluation.[6][7]

In culturing shrimps water dissolved oxygen should be maintain above 5 mg/L.[8] This can be achieved by adding aeration system using rotary fans which consumes a lot of energy. Frequent use may cause expensive operational cost for fish farmers, [9] in which dissolved oxygen should be monitor to ensures that rotary fans are used when monitored water dissolved oxygen is less than 5 mg/L. as lower dissolved oxygen usually cause mortality to shrimp.

Water with a pH of 7 to 8.5 is usually considered appropriate or optimum for the manufacturing of shrimps. The pH value of less than 7 to 5 can cause delayed shrimp growth and development, while pH value below 5.0 can cause mortality to shrimps. Excessive alkaline in water pH greater than 9.5 may also be detrimental to the growth and survival of shrimps.[2], [10] as pH value is important in shrimp development and growth, this study will monitor and create an evaluation model of water pH value.[11]

Shrimps are able to tolerate salinity from below 0 ppt to a above 40 ppt it does not have much effects in its development and growth but because of the high evaporation rate in several countries like the Philippines, salinity concentration in fishponds could increases during the summer period of the year, because of this salinity may increase to above 40 ppt and thus affect growth.[12] Including the salinity on the monitored water quality parameter will give advantage to this study compared to existing study.

As temperature in brackish pond cannot be controlled it can still give fish farmers information if he/she need to find a different location for culturing shrimp as the optimum temperature is 25-30° C while mortality occurs if temperature drops to 14-15° C, same thing happens when temperature is greater than 36° C. [5], [13] which tells that water temperatures should also be monitored in this study.

A classification in machine learning (or classifier) is a systematic approach in creating classification models base from the input data set; classification technique includes decision trees, neural networks, rule based classifier, and the Naive Bayes classifier.

Each technique uses a learning algorithm to identify a model that best fits the relationship between the attribute set and the input data class labels. The main objective of the learning algorithm is to generate a design with good generalization capability.[14] Decision tree classifier is a simple and most commonly used classification technique. A decision tree is like a series of questions with their possible outcome which can be prearranged in the form of binary trees, which is a hierarchical formation consisting of directed arrow lines and nodes.[15] This study will use decision tree to create a classification model of water quality evaluation for penaus monodon or black tiger shrimp.

METHODS AND PROCEDURE

This study was accomplished by following the step by step procedures in the Rapid Application Development Model[16] of the system development life cycle shown in fig 1.

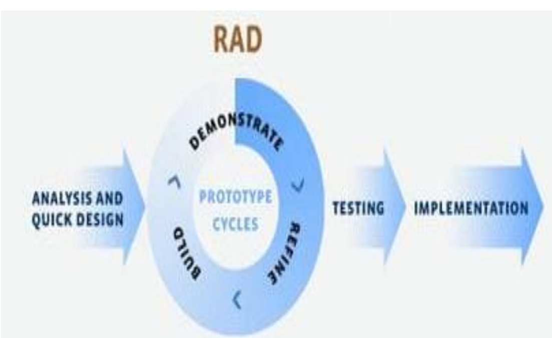

Figure 1. Rapid Application Development Model of SCDLC

This research focused in the development of Water Quality Evaluation System for Prawn (penaeus monodon) using IoT Device and Decision Tree Algorithm. This system will be used to monitor and evaluate water quality for fish ponds that cultured penaeus monodon (black tiger shrimp). To be able evaluate water quality for penaeus monodon, the researcher gather necessary information about penaeus monodon from Bureau of Fisheries and Aquatic Resources BFAR, a local government office in the Philippines. Data from the laboratory from BFAR as instructed by their office were compared, reviewed and validated using published existing studies about penaeus monodon water quality requirements. The office considered that new studies may have new valid results compare to their current data. After the validation of data some adjustment was made as this minor adjustment were accepted by experts from BFAR, some new information was also added from the data given by BFAR which could improved the decision tree classification model for the water quality evaluation.

Hardware Components and Design of the Study

The hardware components are used to monitor water parameters. This includes water Dissolved Oxygen, Electrical Conductivity, pH value and temperature. Ammonia NH_3 is known as a derived value which can be obtained using the pH value and Temperature.[3], [17], [18] Salinity can also be acquired using the value of electrical conductivity. [19]

The hardware component that was used in this study are listed below

1. Gravity Analog Dissolved Oxygen Sensor For Arduino
2. DFRobot Gravity: analog electrical conductivity sensor/meter(K=10) for Arduino
3. PH Meter Sensor Analog Kit
4. DFRobot DS18B20 Full Waterproof Temperature Sensor for Arduino
5. Node MCU 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

The model of the device was created using Fritzing an open-source software of creating circuit prototypes. Device model is shown in Figure 2; this design was used to create the IoT Arduino microcontroller.

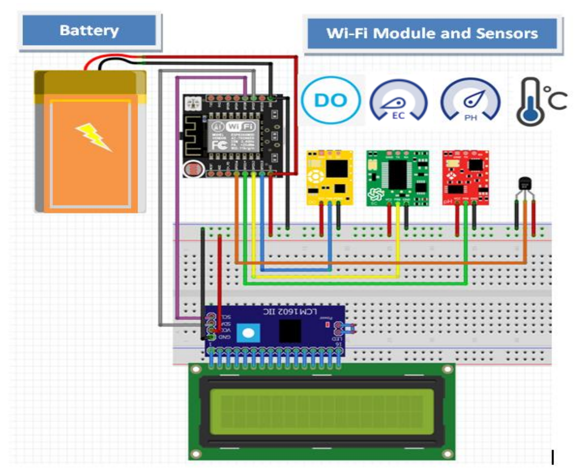

Figure 2. Circuit Design for Water Quality Evaluation System for Prawn (penaeus monodon) using IoT Device and Decision Tree Algorithm.

The microcontroller device will be use to collect water parameter data from fish pond. Through wifi connection the Node MCU V3 ESP8266 will then send the collected water data on the online system to be stored in MySQL database. The stored data will then be evaluated through the use of the water quality evaluation model created using decision tree algorithm.[20], [21]

As ammonia and salinity will be monitored in this study without using ammonia or salinity sensor to reduce the cost of the device, the researcher will use a formula to obtain the ammonia NH_3 measured in milligram per liter (mg/L) and salinity measured in parts per thousand (ppt).

Acquiring Water Unionize Ammonia NH3

The unionize ammonia NH3 can be measured using the obtained pH and temperature data; this can be done by computing for the pKa value first using the formula shown below.[3], [18], [22]

$$pKa = 0.0901821+2729.92/(T\,^{\circ}C+273.2) \qquad (1)$$

Where T = Temprature in DegKelvin

After getting the pKa value the researcher was able to obtain the unionize ammonia NH3 value using the formula shown below. [3], [18], [22]

$$NH3 = 1/(10^{(pKa-pH)} + 1) \qquad (2)$$

Acquiring Water Salinity in part per thousand

To be able to monitor and obtain water salinity, the data from water electrical conductivity was used and calculated using the formula shown below.[23]

$$S\ (ppt) = (EC(mS/cm)^{\wedge}1.0878)\ 0.4665 \qquad (3)$$

Where S = Salinity

EC = Electrical Conductivity

Software Development and Design of the Study

In this study Decision Tree algorithm was selected in creating a model for water quality evaluation to evaluate collected water parameters in determining the suitability and survivability of the aquacultures penaus monodon prawn on the current water quality in the fish pond. This algorithm was selected due to the simplicity of the algorithm which can easily be implemented through series of nested if, else if, and else statements. Shown below is the code representation of the developed decision tree model for water quality evaluation for each water parameter.[24]

Figure 3. Decision Tree Model Code Representation of Water Quality Evaluation on the effect Ammonia NH3 on Penaus Monodon Shrimp

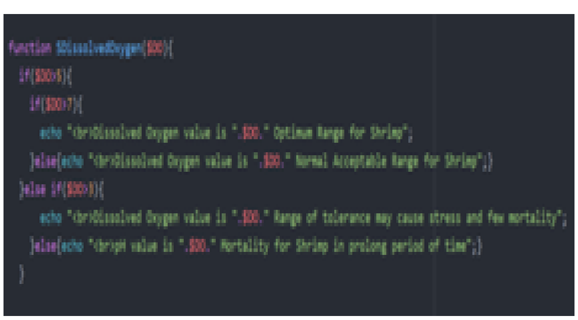

Figure 4. Decision Tree Model Code Representation of Water Quality Evaluation on the effect Dissolved Oxygen on Penaus Monodon Shrimp

Figure 5. Decision Tree Model Code Representation of Water QualEvaluation on the effect pH value on Penaus Monodon Shrimp

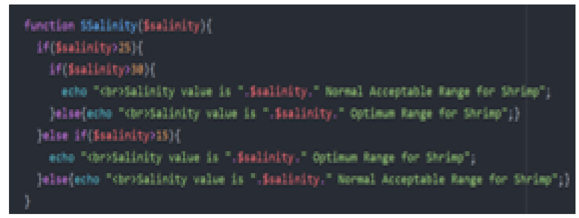

Figure 6. Decision Tree Model Code Representation of Water Quality Evaluation on the effect Salinity on Penaus Monodon Shrimp

Figure 7. Decision Tree Model Code Representation of Water Quality Evaluation on the effect Temperature on Penaus Monodon Shrimp

To validate the created evaluation model, as to make sure that the system provides acceptable expected output, user acceptance testing was done in the office of BFAR in Maimpis, City of San Fernando, Pampanga, Philippines. Two (2) experts in aquaculture and one (1) IT staff were invited to test the system, then after was ask to answer survey questions.

Systems evaluation / Acceptance Testing

The proposed system was evaluated by a pool of three experts: two are from BFAR, a water quality and aquaculture experts and one IT expert form the department.

The researcher designed an assessment method based on the five-point Likert scale model. presented as follows:[25]

Scale	Range	Descriptive Evaluation
1)	1.00 – 1.49	Not Acceptable
2)	1.50 – 2.49	Fairly Acceptable
3)	2.50 – 3.49	Moderately Acceptable
4)	3.50 – 4.49	Acceptable
5)	4.50 – 5.00	Very Acceptable

System criteria

A model was created for classifying the system quality attributes for both functional & non-functional requirements:[26]

- ✓ **Functionality** - Ease of operation, provisions for comfort and convenience.
- ✓ **Usability** – Easy to manage, simple to recall and convenient to run.
- ✓ **Reliability** – Compliance with the desired result, lack of failure and consistency of results.
- ✓ **Performance** - Criterion of requesting the evaluator to respond if the system has fast responds time, processing speed, and the efficiency of the result.

The project evaluation was based on the system for classifying requirements. The criteria used in the evaluation include Functionality, Usability, Reliability, Performance and Security based on the FURPS evaluation system.

Statistical Treatment

To evaluate the system according on its functionality, usability, reliability, and performance the developer conducted an evaluation. The developer first explained the purpose of the assessment to the respondents to ensure that the respondents understood the purpose of the questionnaires; then researcher demonstrated how the system works with its full functionality and from that, the respondents must fill out the questionnaire that was given to them to evaluate the system.

Statistical treatment of data

The data obtained from the respondents were systematically tabulated in order to obtain accurate information on each element of the target population.

This research used the means to measure the findings of the survey. The mean is defined as the average of N numbers determined by adding the sum function of the number and dividing it by the sum function of N. The N reflects the number of respondents who evaluated the system.

Formula of mean is:

$$\therefore M = \frac{\sum x}{N}$$

where M = mean

x = each score or item

N = number of items

$\sum$ = sigma, which means 'summation of'

Table 1 shows the numerical ranking of each criterion in the assessment instrument, which has a scale of 1 to 5, with 1 being the lowest., implies that the system lacks the requirement that is needed by the spectator and 5 being the highest which implies that the system passed the expectation of the evaluators.

Table I. Numerical Ranking

Number Scale	Interpretation
5	Excellent
4	Very Good
3	Good
2	Fair
1	Poor

The data gathered was computed by using the Mean Range Formula for the interpretation of the results.

This statistical treatment of data greatly helped in the development of the system because of this tool, the researcher was able to interpret data in an unbiased manner.[27]

RESULTS AND DISCUSSION

After the water quality evaluation model was created and implemented through PHP code which was integrated to the online system that stores collected data from the IoT micro controller device as shown in Figure 8.

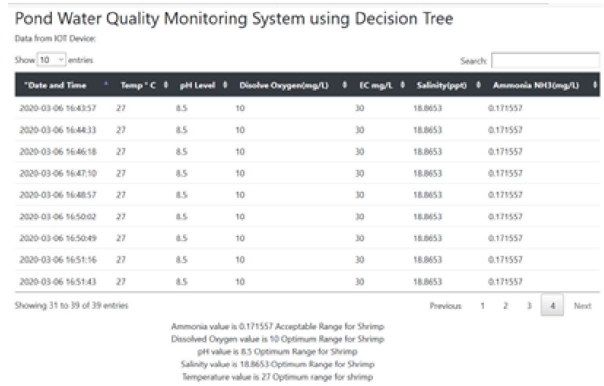

Figure 8. Water Quality Evaluation System for Prawn (penaeus monodon) using IoT Device and Decision Tree Algorithm

The Water Quality Evaluation System for Prawn (penaeus monodon) using IoT Device and Decision Tree Algorithm is now able to produce output for water quality evaluation which is very acceptable according to the user acceptance testing result.

As a whole, the experts evaluation of the system's acceptability is 4.69, interpreted as "very acceptable". Water Quality Evaluation System for Prawn (penaeus monodon) using IoT Device and Decision Tree Algorithm is recommended for deployment or implementation.

Table II. Water Quality Evaluation System For Prawn (Penaeus Monodon) Using Iot Device And Decision Tree Algorithm

Criteria	Weighted Mean	Experts' Response Description
Functionality	4.55	Very Acceptable
Usability	4.55	Very Acceptable
Reliability	5.00	Very Acceptable
Performance	4.66	Very Acceptable
Overall weighted mean	4.69	Very Acceptable

CONCLUSION

Water Quality Evaluation System for Prawn (penaeus monodon) using IoT Device and Decision Tree Algorithm was tested and evaluated as very acceptable by the expert from BFAR the system is commended for implementation specially on fish ponds that has the means to obtain and maintain the IoT microcontroller device and online system as implementation for this system is a little expensive which requires internet connection needed by the IoT device, web hosting site for the online system that collects data, setup and installation cost.

As the Water Quality Evaluation System for Prawn (penaeus monodon) using IoT Device and Decision Tree Algorithm was able to monitor and evaluate water quality in fish ponds accurately. It is sure provide positive impact on fish farmers that cultures penaeus monodon shrimp. It is expected to provide better water quality for fish ponds which can reduce aquaculture mortality, promote healthier environment which boost aqua culture development and growth which can increase possible income for fish farmer.

RECOMMENDATION

Water Quality Evaluation System for Prawn (penaeus monodon) using IoT Device and Decision Tree Algorithm was created especially for penaeus monodon aqua culture, the system can still be enhance by adding evaluation for other aqua culture to be able to help other more fish farmers. It is also recommended for the future researcher to create a mobile application as the main graphical user interface for the user to make it more direct and much easier to use instead of going to web browser to access the system.

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BIOGRAPHY

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