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Improval of Water Quality in Aquapro

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Abstract—The current method of raising tilapia in the Philippines is through fish ponds exposed to the weather. Methods for measuring pH, temperature, dissolved oxygen, andammonia are limited to manually using a chemical test kit. The current system relies on manually regulating the water quality sothe fish are at risk of harmful situations resulting from unsafe levels of temperature, pH, dissolved oxygen, or ammonia. This study aims to solve that problem by creating a system that automatically measures and regulates the pH, temperature, dissolved oxygen, and ammonia. This study takes advantage ofelectronic sensors for pH, temperature, and dissolved oxygen, while computing the ammonia factor, to allow the user to measure the levels of the said parameters at any given time, process, send the data to a LabVIEW database, and use the datato automatically take corrective action against harmful levels ofpH, temperature, dissolved oxygen, and ammonia while notifyingthe user through SMS. The proponents of this study built theprototype and tested it on two different trials of 50 fingerlingseachina1cubic-meter glassaquarium.

Keywords—Tilapia farming, pH, Temperature, Control Actuators ,Ammonia

I. INTRODUCTION

Tilapia farming is a very large industry in the Philippines.The Philippines produced 260,525.67 metric tons of tilapia in2012 [1]. Fish farms are all over the country usually raise thefish in containers fresh-water lakes or large man-made ponds; them a jority with a commondepthof70-80cm[2]. The current system leaves the fish out doors and exposed to elements. The fish are vulnerable to situations where the pH,temperature, DO, or ammonia levels become harmful. It onlytakes one of those parameters to be at a lethal level for entirebatches of fish to die off and cause major losses for the wholegrowing cycle. This requires constant vigilance which can be cumbersome for the staff. This study intended to provide a solution for such events.The system proposed is meant to provide a means to providereal-time measurements and regulation for pH, temperature,DO, and ammonia. The system was designed to measure andautomatically take corrective action as soon as harmful levels of any of the said parameters are detected to reduce the possibility of fish kill.Thesystemtakesadvantageofelectronicsensorstoprovidereal-time parameter measurements ,a controller to process, store the data, and automatically take corrective action when needed, perform thesaid corrective action while notifying the user through SMS. Elements found in previous studies and recommendations were integrated to design this system.

II. LITERATURE REVIEW

The National Aqua culture Sector of the Philippines observed the typical method of raising tilapiain the Philippines involves placing the tilapia in large outdoor ponds, pens, and cages. These containers are usually placed in fresh water lakes or man-made ponds. The tilapia are fed and sample do retransferred when necessary. It is usually an affordable and basic setup [3].The Metropolitan Fishing G roup based in Singapore usesDissolved Oxygen (DO) sensors to monitor the DO levels oftheirfish tanks. When the sensors detect critically-low levelsof DO, their system immediately notifies the staff to manually replenish the DO through operating a special pump. Their tanks also use electronic filters to ensure optimal water qualityfor their fish.[4]. It is recommended that future studies utilizea database to record data trends, and a GSM module to notifythe userremotely[5].In the area of real-time pH measurement, a research group explored the use of Ion Selective Electrodes(ISE) in measuring ammonia and the pH levels of a solution. They fabricated their own ISE's by combining a disposable potentio metric create nine with a disposable solid-state reference electrode. According to the data, the ISE had a very quick response time of about less than 30seconds and exhibited good operational stability [6].In the area of raising tilapia fingerlings, a research grouptested the effect of stocking density on growth of male tilapia fingerlings. The proponents used five different stocking densities: 0.125, 1, 4, 12, and 20 fingerlings /m^2 in 32m^2 concrete ponds with a depth of 90cm. Their growing period was 8 weeks. According to their data, the biggest stocking density, 20 fingerlings per square-meter, had the highest mortality rate and the lowest growth rate (0.43 g/day). Theirsmallest stocking density had the best monthly growth rate(3.03g/day)and thelowestmortalityrate [7].The pH is measured through a gel-filled glass pH sensorand corrected by dispensing fish-friendly pH buffer solutions according to the pH of the system: alkaline for low-pH situations and acid for high-pH situations. The temperature is measured though a thermostat-based stainless steel sensor. High temperature is corrected by draining part of the water and replacing it with colder water by pumping it from a separate reservoir. The DO content is periodically sampled every 30 minutesand usually maintained by constant aerations. Low DO levels are corrected by an auxiliary air pump. The ammonia factories computed based on pH and temperature using the equation below derived from Millichip [10].The ammonia factories indirectly controlled by controlling the pH and temperature.

Forestry and Fisheries (DAFF) in Sea Point (33.9169°S, 18.3875°E), Cape Town, South Africa. The experiment was conducted in a recirculating aquaculture system (RAS) consisting of 12 black, high-density polyethylene grow-out tanks, (465 L capacity, 67 cm deep and 94 cm diameter) with flattened conical floors coated with white fibreglass resin to allow for better fish visibility. The seawater temperature and dissolved oxygen were maintained at 25 ± 0.16 °C via a heat pump and 5.8 ± 0.25 mg.L^{-1} via airlines, respectively. The salinity averaged 34.1 ± 0.12 ‰. The filtration system included the protein skimmer or foam fractionator, the sand filter and the biological filtration. Ultraviolet lights (55 W) were fitted on the water route between the filtration system and the fish holding tanks.

III. SYSTEM DESIGN

A. System Overview

Theproposedsystemofthisstudyiscomposedofanaquarium system, pumps, correction devices, their respectiveactuator circuits, a controller, GSM modules, and a database.The system measures the pH, temperature, DO, and relativewater level of the aquarium system through analog sensorswhile the ammonia factor is computed based on the readingsforpHandtemperature.Thesensorsproduceananalogv oltagethat is read by the controller and converted to digital readingsthat are immediately recorded in a database after conversion. The parameter readings are compared to programmed set-points based on the safe limits of each parameter for fish. Should any of the parameters outside the saferange, the system automatically takes corrective action by actuating there spective correctional devices and immediately notify the user through SMS. Once the system completes self-corrective thesaid parameter the corrective action is stopped and the systemnotifies the user. The figure below shows the overall blockdiagramofthe system.

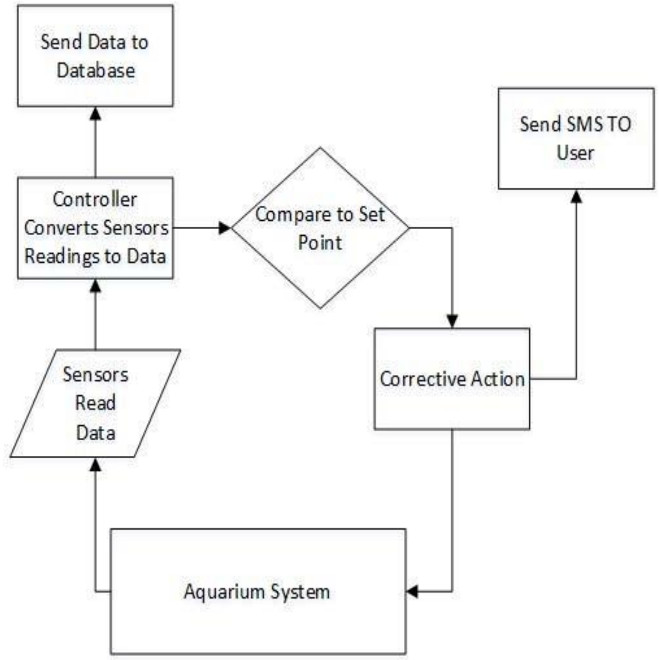

Fig.1.Systemblockdiagram

A=AmmoniaFactor
T_C=TemperatureinCelsius
ph=pH reading

B. Prototype Design

The prototype used in this study is an aquarium tank that ismounted with the various corrective devices, sensors, and amain circulation mechanism. The aquarium itself is a 30 by 54 by 40 in glass tank that holds 1m^3 ofwater. ThetwopHsolution containers were mounted above the aquarium while the reservoir and the reservoir was placed behind the t an k where a pump would transfer water from there to the tank. An airpump with tubes connected to air-stones provided constantaerationin thebottomtank. The main pump takes in water from the bottom of theaquarium and pumps it to a filter above the aquarium. Thewater would pass through a filter that removes the fish waste and food particles before being read by the sensors and dropped back into the aquarium. The main drain is integrated with the piping so water can be flow out of the system at adecentrate. The sensors were placed in specific positions to a void electrical interference between them. The pH sensor was in direct cont act wi the water, the temperature sensor was inside container that electrically (but not thermally) isolated the sensor from the water, and the dissolved oxygen sensor wasconnected to a water sampling circuit that takes water out ofthe aquarium for sampling. All sensors were calibrated once aweek during testing and the grown period. The figure belowshows a diagram of the actual prototype that raised the tilapiain this study. Two water level switches were used to determinewhetherthewaterlevelwastoohighortoolow(onefore ach).

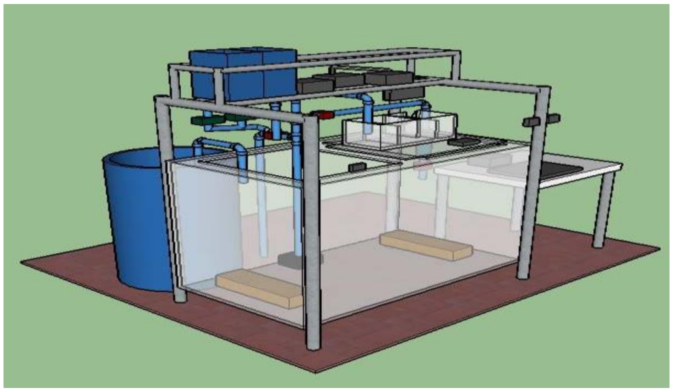

Fig. 2.Prototypediagram

TheprototypeusedtwoArduinoMega2560microcontrollers to process the data from the sensors, controltheir respective corrective devices, send SMS to the user, andsend parameter readings to a database on a laptop computer[11].AllfunctionsrelatedtopH,temperature,ammonia factor,and water level were handled by one controller (Arduino 1);while all functions related to DO levels were handled by theothercontroller (Arduino2).

The protein content of the Aquapro® diets in the current study was 485.53 g.kg^{-1} on average, which was an insignificant difference from 473.7 g.kg^{-1} recorded in an earlier study for a diet with Aquapro® as an additive. The control diet in the current study and Madibana et al. recorded a protein content of 916.9 g.kg^{-1} and 482.6 g.kg^{-1}, respectively. Protein content was singled out for comparison because it is the largest component of carnivorous fish diets, and it is the most expensive nutrient. In fish, proteins and their amino acids play a significant role in many functions, including growth processes and cell renewal. The inclusion of Aquapro® as an additive did not in any way compromise the protein content of diets in the current study. Using a similar commercial herbal product as used in this study, Dada and recorded a protein content of 422.5 g.kg^{-1} and 425.3 g.kg^{-1} for Aquapro® diet and the control, respectively. Different basal diets (fishmeal) and formulations may explain significant varying protein content of our earlier study and the current study with that of Dada and .The current study used local South African fishmeal which is comprised of pelagic fish such as anchovy Engraulis capensis Gilchrist, 1913, pilchard Sardinops ocellata (Pappe, 1853) , red eye Etrumeus whiteheadi Wongratana, 1983, Atlantic horse mackerel Trachurus trachurus (Linnaeus, 1758) and lantern fish Lampanyctodes hectoris (Günther, 1876).
harengus Linnaeus, 1758 and menhaden Brevoortia tyrannus (Latrobe, 1802) (Ahmad and Ibrahim, 2016).

IV. SOFTWARE IMPLEMENTATION

A. Arduino Programming

Arduinowasthesoftwareusedforprogrammingthe Arduinomicrocontrollers[12].Eachmicrocontrollercontinuously repeats a programmed cycle where each assignedparameter is measured, compared against the set-point, andthen dealt the corresponding corrective action if needed [13].Every hour, the system updates the user of the current level ofeach parameter through SMS. The figure below shows theoverallcycleofthecontrollers.

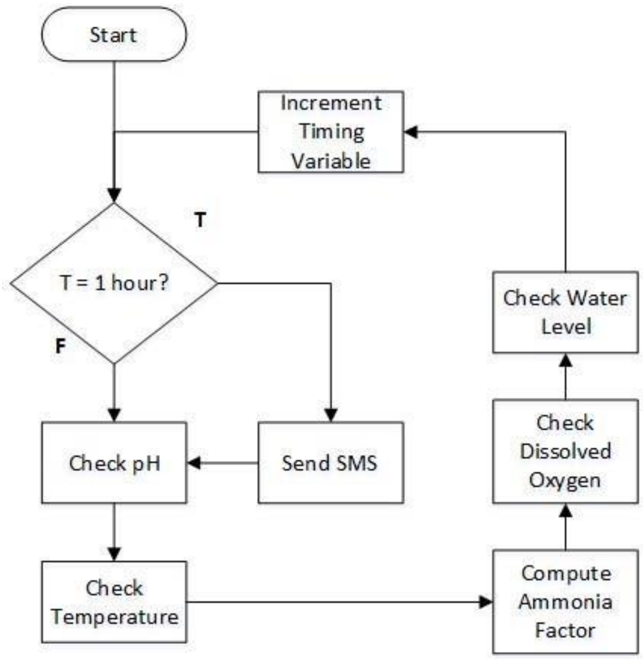

Fig.3.Arduinoflowchart

TheArduino1handlesfunctionsrelatedtopH,temperature, ammonia factor, and water level. The pH andtemperaturewereeachmeasuredforasamplingperiodof10 minutes while every reading was sent to the database.. The flag variableis the basis for halting corrective action and the follow-upmessage once the parameter reaches the safe limit upon thenext checking time. Figure 4.shows the flowchart for pH, temperature, and ammonia factor (computed).Arduino 2 handles functions related to DO. The controllersamples water from the system every 30 seconds to isolate itfrom the other sensors. When the water is sampled, the DOsensor measures the DO level and the controller stores that value in the database, comparesit to the set-point, and activates the auxiliary air pump if needed. Figure 5 shows the corresponding flowchart.

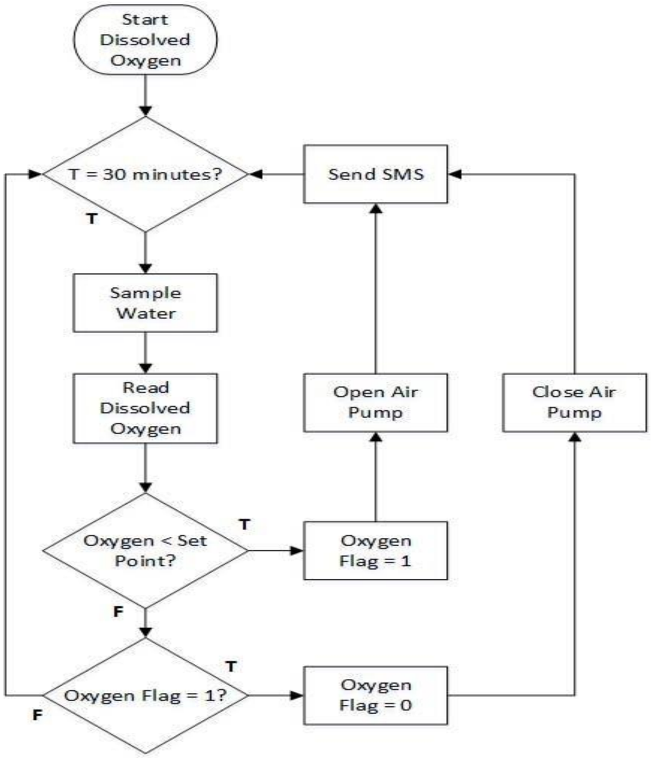

Fig. 4.TemperatureandpH flowchart

A. LabViewDatabase

Lab VIEW is an integrated development environment software made by National Instruments, a program specifically for visual programming and system-design platform for creating custom applications that interact withdata or signals. LabVIEW is also used to interface hardware devices for data collection by example[14]. Lab VIEW programs are called Virtual Instruments(VI) as this simulate in appearance and operation of physical instruments. Each VIhas a front panel and a block diagram. Front panel is the userinterface of the program while block diagram is the graphic also source code of the program [15].Lab view is used as the real time display and extraction of parameter (Calculated Ammonia factor, Dissolved Oxygen, pH, and Temperature) data from the Arduino boards to LabVIEW[16]. “Equal? function” and“ Replace Substring function” from the block diagram is used to segregate the raw data to their respective parameter “Case Structure” that goes through indicators, plots, and charts. Inlayman’s terms, LabVIEW detects the corresponding character that is coming from the raw data to segregate the parameter data so if LabVIEW detects the character “p” from the incoming rawdata LabVIEW would treat the incoming raw data as pH, if character “t” it means for temperature, “a” for calculated ammonia, and “d” for dissolved oxygen. Write to Measurement file Express VI isused as the automatic extraction of parameter data for every 1 hour interval in excelformat.

V. METHODOLOGY

There were two trials of using the prototype to raise 50tilapia fingerlings each. The growing periods for both trials lasted 28days. Prior to the start of the growing period, three (3) samples of 10 fingerlings each were weighed to record theinitialweight of each fingerling. The same process was done at the end of each trial to determine the final weight. During the trial period, the fish were fed twice a day. Onceat 8am and once at 4pm. Dead fish were immediately removedfrom the aquarium to reduce any additional ammonia. Theprototype didn’t require frequent maintenance but required thefiltertobe changedat leastonce per trial. Instead the originally planned weekly weight sampling, theproponents sampled the final weight at the end of the trial tominimize the stress on the fish during the growing stage. Thesame sampling procedure was used, three (3) samples of 10fingerlings each, was used to measure the final weight. Theinitial and final weights of each sample were compared and used to compute the growth rate for each trial.

In an operating water system, the measurement of ozone by titration or by kit is costly, requires many operational steps and is therefore difficult to use for continuous monitoring in a short time. The oxidation–reduction potential (ORP) is used, because it is easy to measure with handheld or automatic measuring devices, which can monitor fluctuations over short intervals. ORP is an index of the oxidation capacity of water at the measuring point. In water, oxidizers can be oxygen, chlorine, peroxide, ozone or any other oxidizing chemicals. In clear waters, ozone content is directly proportional to the ORP values. To gain a better understanding of how NBs increase the oxidation–reduction potential within our experimental set-up, we recorded ORP changes over one-minute intervals with a handheld ORP meter. ORP values may serve as a simple, rapid and real-time proxy indicator for ozone concentration in water. ORP values may also serve as a simple, rapid and realtime proxy indicator for ozone concentration in water and is commonly used by aquaculture operators instead of ozone measurements through titration due to the complexity, cost and time required to process samples. Since contaminants in water (from salt, bacterial or Nutrient Broth media used in experiments) interfere with ORP readings, we conducted OPR reading on the NB generator in freshwater to eliminate biased ORP readings caused by ‘dirty’ water. The pre-trials were set up with the three NB gases (air, oxygen, ozone), replicated three times and ran for 15 minutes each. Other pre-trials were carried out to test the NB dosages of different gases.

VI. RESULT

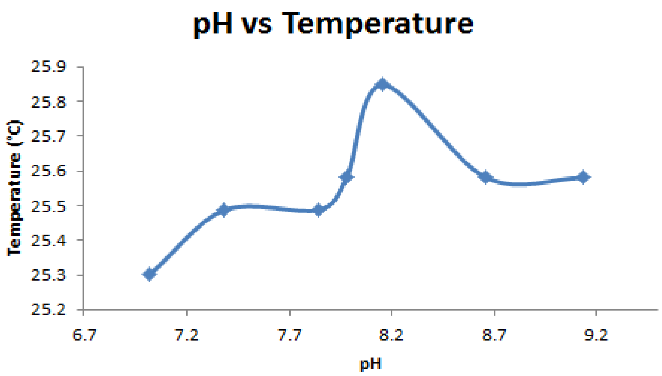

Fig.5.pHvs.temperaturecorrelationgraph

A. ParameterCorrelation

Since the system alters different parameters in the same body of water it was important to note how a lterring one parameter affects others. The proponents varied pH and temperature and determined their effects on the other parameters. When altering the pH, it was discovered that it does not have a direct effect on the temperature. The graph does show adefinite trend in the data and the correlation-coefficient (r)was 0.554565998. That suggests there is a weak relationship between these two parameters. Figure 6 shows the visual relationship. When increasing the pH, it was also discovered that the ammonia factor increases exponentially. This verifies the findings of Millichip. Since the hydroxide and ammonium on vert to ammonia and water molecules, more hydroxideions present (higher pH) result in larger toxic ammonia content. Figure7 shows the visual relationship and the equation describing the relationship in the typical range for pH in waterforraisingfish.

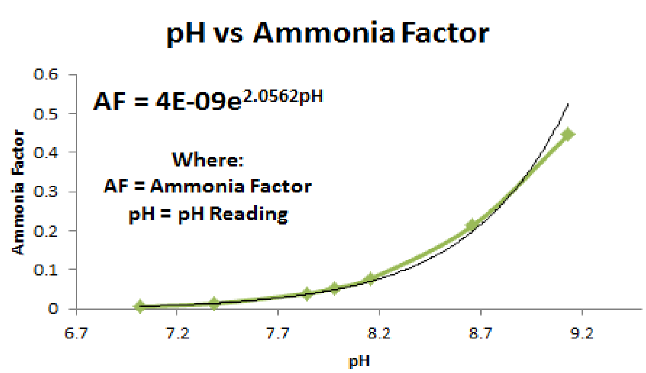

Fig.6.pHvs.ammoniafactorcorrelation graph

When the temperature increases ,it was discovered the ammonia factor slightly increases in almost a linear fashion. The correlation coefficient was 0.992385036 so that suggest a When the temperature increases, the DO content slightly decreases in a line are manner. The correlation-coefficient calculated was -0.975640054. This suggests a strong lineararrelationship between the two parameters. Figure 9 shows thevisualrelationship

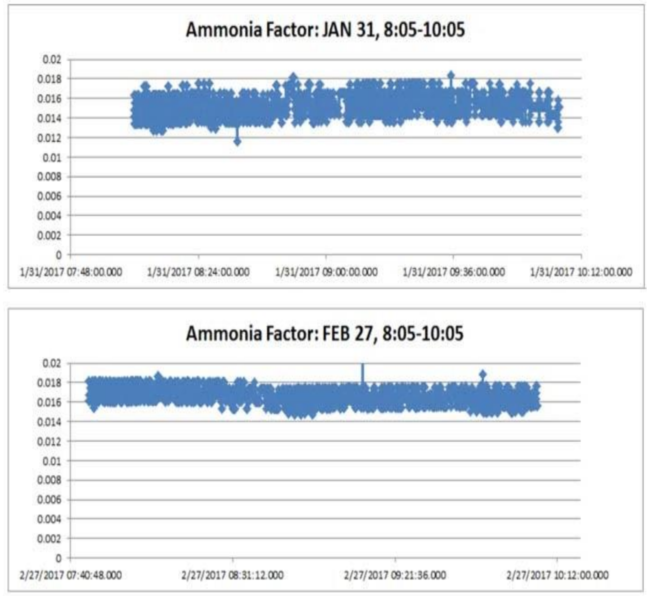

Fig.7.Ammoniafactorreadingsduringfeedingperiod

for comparison, it was discovered that the growth rate of the previous study were better than both trials. It was discovered that the quality of feeds in their study were superior to the locally available feed for this study since they addedprotein content in their feeds. Their filtration system was alsomore efficient because it effectively removed fish waste andfood residue at the bottom of the tank. It is believed that thesebiological factors have a very significant effect on growth rate on the fish compared to the water quality in terms of the parameters controlled. The only major change was a 0.01 increase in pH while the other parameters weren't significantly affected. With that change in pH(and possibly ammonia factor) noted, the proponents looked through the parameter data for pH and ammonia factor during the feeding time of two days in a trailperiod: one day during the beginning of the trial, and one daytoward the end of the trial. According figure 10, there weren't any significant increase trends in pH and ammonia factor. Given the results it can be concluded that direct administrationof feeds to the water does not significantly influence the pH, temperature, ammonia factor, or DO.

VI. CONCLUSION AND RECOMMENDATIONS

In conclusion, the prototype of the proposed system was able to measure, monitor, and regulate all the pH, temperature,DO, and ammonia factor of the aquarium system. Real-time measurement of pH and temperature was relatively easy due to the durability of the sensors. DO was the most difficult tomeasure because the sensor required periodic sampling andelectrical isolation from the other sensors. Its delicate structureand made it difficult to give real-time measurements overtime.The prototype itself was able to regulate the parameters for thefingerling,butwasn’tabletomatchthegrowthrateofprevious studies. This can further be improved by improving the fish feed sand the filtration system. For future studies in this area of research, it is recommended that the sensors, the biological factor, and the database be improved. In the area of sensors and measurement, it is highly recommended to obtain sensors that are more durable and donot require frequent calibration because this usually disruptsthe system’s data gathering. Also, it is recommended to find a more consistent and more effective way to electronically measure dissolved oxygen as the sensor used was delicate and required maintenance. In terms of biological factor, the tank of the fish should beimproved to effectively remove waste and food residue fromthe bottom of the tank. In addition, rather than limiting the system to a tank setting, the system could be applied and adjusted to pond settings since ponds are the most commonway to raise tilapia in the Philippines. it is recommended to improve the quality of the food and have longer growing periods for better results.

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