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ARDUINO-BASED AQUARIUM CONTROL SYSTEM

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ABSTRACT

Aquaponics is a system of aquaculture in which the waste produced by farmed fish or other aquatic creatures supply the nutrients for plants grown hydroponically, which in turn purify the water. The main goal of Aquaponics was to reuse the nutrient release by fish. By manipulating this natural phenomenon, the researcher design and build an Aquaponics system that was capable of sustaining plant growth. The researcher designed and assembled an Arduino-Based Aquarium Control System and determined its performance level and acceptability. The study utilized the experimental method in designing and assembling the device and determined the occurrences during the process. Descriptive method was also utilized to gather information in a form of a survey questionnaire to determine the acceptability in terms of performance, convenience, safety, durability, and cost. The result of the study revealed that the performance level and acceptability of the Arduino-Based Aquarium Control System is highly acceptable with the overall rating of 3.53 interpreted as very high. The performance of the device got the highest rating of 3.69 and described as “Very High”. Cost was ranked lowest with an average weighted mean of 3.15; although ranked lowest, the researcher made entirely a whole package of the aquarium system making the device expensive. The Arduino-Based Aquarium Control System is more efficient due to its performance. The improvement of the device with the use of other microcontrollers or GSM allows remote monitoring of pH level, dissolved oxygen and temperature for future developments and designs.

KEYWORDS: Aquaponics, Arduino, Aquarium Control System, performance, acceptability.

INTRODUCTION

The use of technology really made people's life more interesting and productive as well. It is said to be the best contribution in its improvement, especially with an aid of a computer; thus the computer operates machines nowadays. Hence, the research proposed to develop and design an Arduino-Based Aquarium Control System. It is a device that helps in the difficulty encountered in the Aquaponics system were maintaining optimal levels of production and the time it takes to monitor and manually reset parameters to the required amounts.

Aquaponics is a system of aquaculture in which the waste produced by farmed fish or other aquatic creatures supply the nutrients for plants grown hydroponically, which in turn purify the water (Sawyer, 2013). The main goal of Aquaponics was to reuse the nutrient release by fish. By manipulating this natural phenomenon, the researcher can easily design and build an Aquaponics system that was capable of sustaining plant growth.

In this study the researcher makes use of an Arduino microcontroller to serve as the central controller in the Aquaponics system. As an evolving study regarding Aquaponics, this study could compliment a good impact to the research of the field in electrical as well as agricultural fields. The researcher's study focuses on monitoring and controlling the pH level, dissolved oxygen level, temperature, water level and output controls such as pumps, aerator, and fan.

At present, there are wide variety of devices and equipment that are developed through constant research and studies. This allows engendered knowledge to be used and be transferred to the industry to benefit the economy for sustainable development. New lifestyle emerges out of novel, scientific processes and modern technology that constitute changes to human life (Bastes, 2016).

Sensors have contributed significantly to recent advances in manufacturing technology. Using a sensor makes a process or system more automated and minimizes the need for human operators to monitor and control the situation. Sensors serve as actuators which are converted into signals and may respond to an input quantity hence, generating functionality (Brede, 2007).

Temperature sensors, pH level sensors and Dissolved Oxygen Sensors are the type of sensors used in the study. A temperature sensor is a device, typically, a thermocouple or Resistance

Temperature Detector (RTD) that provides temperature measurement through an electrical signal. A thermocouple (T/C) is made from two dissimilar metals that generate electrical voltage in direct proportion to change temperature. An RTD (Resistance Temperature Detector) is a variable resistor that will change its electrical resistance in direct proportion to change temperature in a precise, repeatable and nearly linear manner (Herman, 2010).

Temperature affects the solubility of oxygen in water (Muha, 2007). Thus, a good range of 76°F to 80°F (25°C to 27°C) is the average temperature of an aquarium tank. A few species need to be kept several degrees warmer 28°C to 30°C, and some species require temperature a few degrees cooler 14°C to 16°C. The temperature sensor monitors the temperature inside the tank to help fish maintain metabolic functions.

PH level sensors measure the level of pH in sample solutions by measuring the activity of the hydrogen ions in the solutions. PH is measured in different applications: medical, environmental, food production, safety appliances and for process control in industry (Chinnam, 2009). Whether the water is either too alkalic or too acidic it can wreak havoc on fish by interfering with their basic body functions, leaving them vulnerable to disease and stress. The pH balance should observe in an aquarium environment. The average pH level of aquarium fish ranges from 5.5 pH – 8.5 pH, depending on some of the specific species.

Dissolved oxygen sensor, on the other hand, is used to measure the amount of oxygen that is dissolved in water, by unit volume. The amount of oxygen that a given volume of water can hold is a function of the atmospheric pressure at the water-air interface, the temperature of the water, and the amount of other dissolved substances. The concentration of dissolved oxygen (DO) is usually expressed in milligrams of oxygen per liter of water (mg/L) or parts per million (ppm). Some meters compare calculated oxygen content with observed concentration and report percent saturation (% sat.).

An aquarium tank must be maintained regularly to ensure that the fish are kept healthy. Daily maintenance consists of checking the fish for signs of stress and disease. With the use of the mentioned sensors, the researcher can pinpoint the parameters to be recorded and controlled. An output device such as pump motor, aerator and fan are used to control these parameters.
Pump motor is used to provide filtration system and water movement in the aquarium. The water from fish tank is pumped to the plants. It contains bacteria converted to ammonia and nitrite to nitrate and absorb this nutrient by the plant. Filtered water is returned to fish tank

clean. Proper water movement also plays an important role in the aquarium for the fish's health and maintains water quality.

Aerator provides aerobic respiration in the water. Aeration is an important factor in an aquarium environment due to the survival and growth condition of all organisms living. It is an indispensable operation, and its main purpose is to dissolve the oxygen into the water. In addition, many species of fish will not thrive without proper currents in the tank and currents prevent detritus from accumulating.

Fan is used to control the temperature inside the aquarium. Proper temperature of aquarium is an important factor in the health of the fish because fish cannot regulate their body temperature. They are dependent on the water temperature for their body temperature.

Arduino-Based Aquarium Control System is an innovation for learning and knowledge. It creates better opportunity for innovators to have a device that applies a great solution that meets new requirements and needs to the existing market. It is original and more effective, as a consequence, it is something new, and that breaks into the society.

Objective of the Study

The main purpose of this study was to designed and assembled an Arduino-Based Aquarium Control System and determined its performance level. Moreover, assess its acceptability to aquarium owners and fish enthusiast.

METHODOLOGY

Design

The study utilized the experimental method in designing and assembling the device and a descriptive method was utilized to gather information in a form of a survey questionnaire to assess its acceptability. Observation guides are also made to determine the performance level of the device. In doing this, the researcher determined the occurrences during the process.

Environment and Participants

The study was conducted at Bohol Island State University – Main Campus, Tagbilaran City. This institution is the locale of the study because it offers Industrial Technology Courses particularly Electrical and Electronics Technology Courses.

The researcher selected twenty (20) owners and enthusiast of aquarium tanks to test and validate the level of performance and to assess the acceptability level of the Arduino-Based Aquarium Control System.

Instrument

To obtain necessary data, the researcher constructed a questionnaire to check the appropriateness of the device based on the following:

1. Observation Guide. It is a series of descriptive statements which determines the capacity of the device to test its performance level.
2. The Questionnaire. It contains a set of questions at a pre-determined number of subjects to gather information on the acceptability level of the device in terms of its performance, convenience, safety, durability and cost.

RESULTS AND DISCUSSIONS

This chapter presents the findings, analysis, interpretation, and project design of the study. It also presents the data gathered, collated, and tabulated in accordance with the appropriate statistical treatment. The output observed of the Arduino-Based Aquarium Control System and its performance level were graphed and tabulated in detailed.

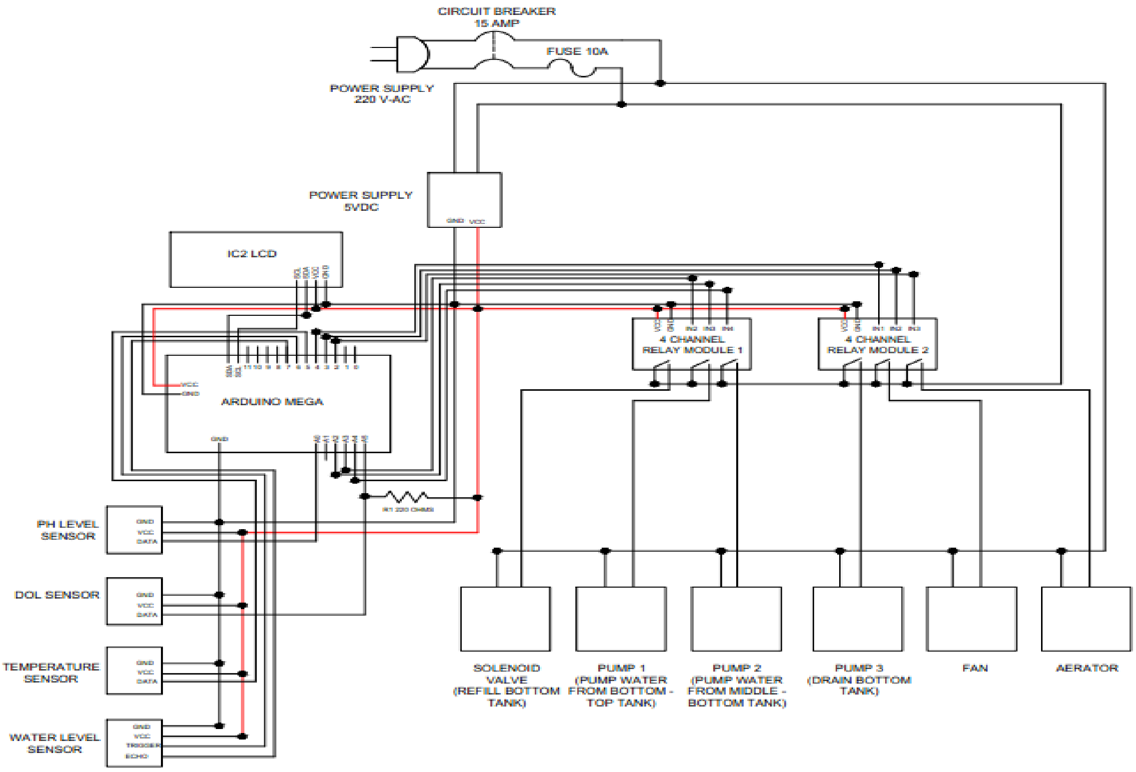

Figure 1: Schematic diagram of Arduino-Based Aquarium Control System.

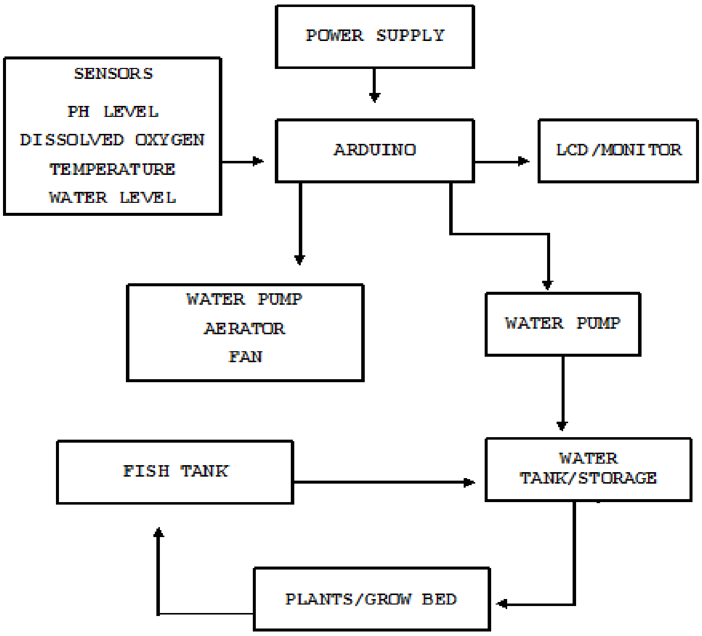

Figure 2: Block Diagram of the Arduino-Based Aquarium Control System.

Figure 3: Perspective View of Arduino-Based Aquarium Control System.

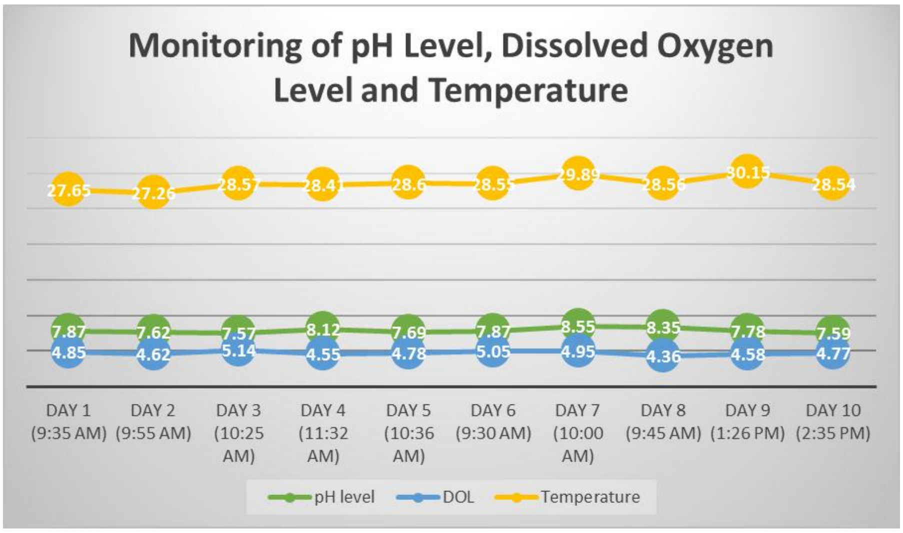

Figure 4: Monitoring of pH Level, Dissolved Oxygen Level and Temperature.

Figure 4 shows the real time condition inside the aquarium. The researcher observed the daily measurement values of the sensors.

The first parameter observed is the pH sensor level where pH level measured is in a steady state with a range of 7.5 – 8.50 pH level. The pH level is one of the important parameters. At pH level 7.0 below, the Nitrosomonas grows slowly and the increase in ammonia will be evident. At almost 6.5pH most of the ammonia present will be mildly toxic, so the pH level needs to be neutralized to have a proper plant and fish growth.

The dissolved oxygen level measured is 4.3 to 5.0+mg/L and needs to prevent the DO level to drop 3mg/L. Dissolved oxygen is important in fish respiration. In practice, fish requires 4-5 mg/L. Example of a clear sign of lack of oxygen is when fish gasping for air at the surface of the water. The fish will swim close to the water surface and take air into their mouths. In this situation, it needs an emergency and immediate attention. The minimum requirement of DO level for the fish is 4, below 3mg/L the fish will die even the hardy one.

Water temperature affects all parameters and aspects of the system. Temperature needs to be at 27.60 – 30.00 degrees Celsius to maintain the body temperature of the fish. In general, the compromised range of the temperature is 18-30 degrees Celsius. Temperature also affects DO and the ionization of ammonia. DO is low when the water temperature is high and creates more toxic ammonia.

To get a stable level of the parameters the pump needs to operate 24hrs.

Table 1: The performance level of the Arduino-Based Aquarium Control System Efficiency of Auto Feeder.

Feeding Times/Day	Trial	Amount (g)	Accuracy Fish Feeding Times/Day	Description
2 times daily at 12 hrs interval	1	12	Operative	Functional
	2	12	Operative	Functional
	3	12	Operative	Functional
3 times daily at 8 hrs interval	1	12	Operative	Functional
	2	12	Operative	Functional
	3	12	Operative	Functional
4 times daily at 6 hrs interval	1	12	Operative	Functional
	2	12	Operative	Functional
	3	12	Operative	Functional

Table 1 shows the performance level of the Arduino-Based Aquarium Monitoring System regarding the efficiency of the auto feeder in terms of amount of food dispatch (mg) and feeding of fish times per day.

Throughout the entire trial the researcher observed that the amount of food being dispatch is approximately 12 grams. The researcher feed the fish 2 times, 3 times and 4 times daily. It is observed that there is no problem encountered throughout the feeding time per day of the fish. Thus the auto feeder performed functionally.

Table 2: The performance level of the Arduino-Based Aquarium Control System Efficiency of Output Devices (Pump, Aerator and Fan).

Sensor	Trial	Operation	Response	Description
pH Level Sensor (reading)	1	7.50 pH	The pump response accordingly.	Functional
	2	8.20 pH	The pump response accordingly.	Functional
	3	8.60 pH	The pump response accordingly.	Functional
Dissolved Oxygen Level Sensor (reading)	1	4.20 mg/L	The aerator response accordingly.	Functional
	2	4.55 mg/L	The aerator response accordingly.	Functional
	3	4.88 mg/L	The aerator response accordingly.	Functional
Temperature Sensor	1	27.56 °C	The fan unable to response.	Functional
	2	28.87 °C	The fan unable to response.	Functional
	3	30.22 °C	The fan response accordingly.	Functional
Ultrasonic Sensor (reading of water level)	1	20 cm	Water level is stable.(Safe)	Functional
	2	30 cm	Refill water to the lower tank.(Warning)	Functional
	3	40 cm	Refill water to the lower tank.(Critical)	Functional

Table 2 showed the performance level of the Arduino-Based Aquarium Monitoring System regarding the efficiency of the output devices.

The first observed sensor reading is the pH level sensor. Throughout the three trials, the sensor reads at 7.50 pH, 8.20 pH, and 8.60 pH respectively. Thus, the pump functions accordingly to neutralize the pH inside the aquarium tank.

The second observation is the dissolved oxygen level reading. The aerator provides aeration to the entire system, thus maintaining a DOL of 4-5 mg/L.

The third observation is the temperature inside the aquarium tank. The temperature should be maintained at 27-30 degrees Celsius. At the third trial the reading reaches 30.22 degrees Celsius lowering down the temperature inside the aquarium tank with the use of the fan.

The final observation is the water level reading. At the first and second trials, the water is at 20-39 cm away from the sensor, as a result, solenoids open to refill water at the bottom tank.

Furthermore, the researcher observed that the operations and responses met the desired functionality of the device.

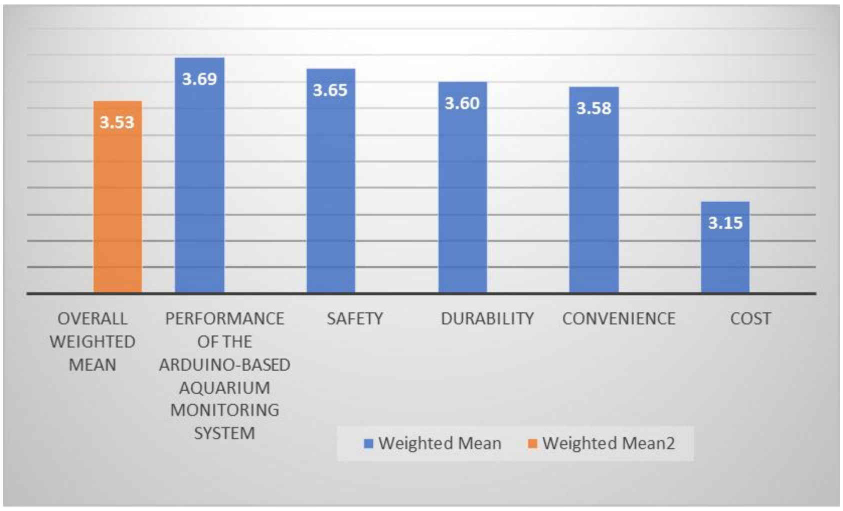

Figure 5: Acceptability Level of Arduino-Based Aquarium Control system.

Figure 5 shows the summary of acceptability level of the Arduino-Based Aquarium Control System in terms of its performance, convenience, safety, durability and cost.

The Arduino-Based Aquarium Control System under “performance” ranked the highest with the average weighted mean of 3.69. The device operation is clearly appreciated by the respondents for it can display real time aquarium conditions and control the operation of the control outputs. The outcome and effectiveness of the device reflects the result of the observations. The respondents were able to see the performance and are satisfied with what the device can perform.

Safety ranked second with the average weighted mean of 3.65. This implies that the device is a good electrical insulator and is properly equipped with short circuit protection. Moreover, the materials used were designed and selected to provide safety to users.

Durability had an average weighted mean of 3.60. It ranked third with the device’s ability to with stand heavy weights, high pressure and temperature, and long process controls are clearly seen by the respondents.

Convenience had an average weighted mean of 3.58. This means that the Arduino-Based Aquarium Control System requires less effort to operate as evaluated by the participants. Although it rank fourth, the device’s convenience to monitor aquarium conditions does not depressed the total functionality of the device.

Cost was ranked the lowest with the weighted mean of 3.15. The Arduino-Based Aquarium Control System was rather expensive because the materials used were guaranteed to have quality to provide better performance during operation since the researcher made an entirely whole package of aquarium system.

The overall weighted mean of the Arduino-Based Aquarium Control System is 3.53 which is still a high rating for the device. The respondents see the operation of Arduino-Based Aquarium Control System and is evaluated accordingly.

Findings

The results of the study revealed the following findings:

1. On the description of the Arduino-Based Aquarium Control System

The Arduino-Based Aquarium Control System is powered by an Arduino, an open-source electronics prototype platform based on flexible, easy to use hardware. The most beneficial outcome to use Arduino was a software that can be downloaded for free and CAD files were available under an open-source license. The availability and cost of the materials greatly helps in the construction and assembling of the device. Proper procedures and operations were followed to ensure the effectiveness and consistency of its operation.

2. On the performance level of the Arduino-Based Aquarium Control System

The Arduino-Based Aquarium Control System was able to monitor the pH level where measured in a steady state with a range of 7.5 – 9.00 pH, dissolved oxygen maintained at 4.3 to 5.0mg/L and temperature inside the aquarium at 27.60 – 30.00 degrees Celsius. The operation of auto feeder and control outputs corresponds to the correct conditions.

3. On the acceptability of the Arduino-Based Aquarium Control System.

The Arduino-Based Aquarium Control System was found to be highly effective in the aspects of performance, convenience, safety, durability, and cost with a total average weighted mean of 3.53. Performance was ranked highest with an average weighted mean of 3.53. Cost was ranked lowest with an average weighted mean of 3.15, although ranked lowest; the researcher made entirely a whole package of the aquarium system that make the device expensive.

CONCLUSION

Based on the findings gathered from the Arduino-Based Aquarium Control System is more efficient due to its performance and showed that this device is effective in its course of application. The parameters are able to control and corresponds to the correct conditions.

Recommendations

Based on the findings, the following recommendations are given to improve the output of the device:

1. Researcher will introduce the Arduino-Based Aquarium Control System to aquarium tank owners and enthusiasts to be able to maintain and sustain efficiently their aquatic animals.
2. To improve the monitoring system, the researcher recommends the use of other microcontrollers or GSM to allow remote monitoring of pH level, dissolved oxygen and temperature.

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