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AN INNOVATIVE REAL-TIME WATER QUALITY MONITORING SYSTEM FOR AQUACULTURE APPLICATION

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ABSTRACT

Aquaculture is one of the most promising industries in agricultural sector. Fish as one of aquaculture's contributions, is considered as a substantial source of protein for people around the world. However, one issue confronting the small-scale aqua farmers is the current practice of conventional water quality monitoring which is a tedious and time-consuming. These current evaluation methods of water quality are laboratory-based tests that required fresh supplies of chemicals, qualified staff and water samples. In this study, an innovative real-time water quality monitoring system for aquaculture application is proposed. The system utilized electronics sensors, microcontroller and SMS technology for notification purposes. There are four parameters, monitored namely: pH, temperature, dissolved oxygen and ammonia. Results of evaluation performance show that there were only minimal errors in the values of the parameters considered in the proposed device as compared with that of a standard device. The device functioned according to its purpose with a high degree of accuracy. The said device is a potential innovative solution to small-scale aqua farmers in mitigating fish kill, thus, increasing yield production.

Keywords: aquaculture, SMS technology, real-time monitoring, water quality.

INTRODUCTION

Aquaculture is one of the most promising industries in agricultural sector. It provides food security, economic growth, employment and more foreign exchange (BFAR-PHILMINAQ, 2007). Fish as one of aquaculture's contributions, is considered as a substantial source of protein for people around the world. However, one issue confronting the aqua farmers is the existing practice of traditional water quality monitoring which is tedious and time consuming. In assessing the water quality of the pond, smallest scale aquaculture industries employ manual water quality monitoring. These current evaluation methods of water quality are laboratory-based tests that required fresh supplies of chemicals, qualified staff and water samples. Unmonitored period for water quality and some bad practices in aquaculture may result to huge number of fish kill occurrences, resulting to low production and economic losses to the aqua farmers. Fish kills have been a huge problem of some fishing farms for over a century.

To address the issues confronting the aqua farmers, an innovative real-time water quality monitoring system for aquaculture was proposed. This study is aimed to design and develop the system which includes an alert feature using Short Message Service (SMS) via Global System for Mobile (GSM). The water parameters that were tested include temperature, pH, ammonia and dissolved oxygen. Furthermore, the study sought to evaluate the proposed device by comparing its performance with that of the standard device.

Water Quality

Intensive, healthy and sustainable aquaculture is the trend of the aquaculture development. Good environment for fish growth signifies good water quality while poor water quality will lead to fish illnesses and even fish kills (Ramson *et al.*, 2018). Water quality is vital for fish farming and water quality real-time monitoring is an important tool to ensure and support high productivity, high efficiency, safety and healthy and low pollutions.

According to the study of Fowler *et al.* (1994), pH, temperature and DO must be checked continuously and on direct basis since they tend to change quickly and have a significant adverse effect on the system if allowed to operate out-of-range. Also, an essential element in determining water quality which impact fish behavior and health is ammonia (Pillay *et al.*, 2005). Thus, these considerations were chosen to be observed in the present system.NH3, or commonly known as ammonia, is a compound of nitrogen and hydrogen, a colorless gas with a characteristic of overpowering smell. Water temperature and pH, together rising alkaline conditions, often lead to rise in the toxic un-ionized ammonia. Also, if DO level fells below the threshold point, fish will suffocate. Fish may die if pH values reach below 5. High pH level is detrimental to fish health as ammonia becomes poisonous. According to Fores (2020), huge fish die-off varies in many factors but, the usual fish kill is caused by warm water, making temperature a very important factor in water monitoring.

Monitoring System

Many monitoring systems in fish farming management have been remotely developed. The study of Nasirudin *et al.* (2011) proposed a smart system to monitor the water quality remotely via SMS. It monitored and recorded real-time data of pH level and DO level. In the study of Silva *et al.* (2011), they used WiMAX and sensors like pH, conductivity, temperature, ORP and DO. The studies of Rasin *et al.* (2010) and Joon-Taek *et al.*

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(2003) used Zigbee based wireless network sensors to monitor real-time temperature, pH level, turbidity. The temperature is measured in real time by the sensors and transmit the data to the base station. Javaraj *et al.* (2020) proposed machine learning and data mining applications in water quality monitoring. Simbeye *et al.* (2014) used LabVIEW software for data analysis and processing.

This research presents the development of an innovative real-time water quality monitoring system for aquaculture application. The temperature measurement used LM 35 circuit with capacitor insulated with plastic material. pH sensor and DO sensor were used. GSM was used for the data received from the PIC microcontroller and Arduino going to the cell phone. Furthermore, audible and visual alerts were included that display the values of water parameters such as temperature, pH, dissolved oxygen and ammonia. When the water quality is out of range, it will send via SMS or an alarm to alert the user or farmer. The developed device is helpful in monitoring the water quality.

METHODOLOGY

System Design and Development

Figure-1 shows the whole system framework of the study. It consists of three components, namely: detecting module, processing module and alerting module. The detecting module consists of four parameters, namely: temperature, pH, and dissolved oxygen while ammonia used the relationship between temperature and pH values. The sensors then measured the corresponding values of the water. Analog to digital conversion was used since sensors are analog in nature and the microcontroller only accepts digital signal.

The processing module includes microcontroller that processed all the data received from the detecting modules. GSM was also used for the data received from the PIC microcontroller going to the cellphone user. The microcontroller sent the measured values to the alerting module in the form of SMS via GSM. In the alerting module, it allowed the user/ farmer to be alerted in three ways: (a) send via SMS using cellphone when the monitored data is out of range; (b) through alarm, the user/farmer nearby is alerted; and, (c) using the display monitor. In this system, the microcontroller sends the measured values to the alerting modules based on the specific time stated in the program. Since it is real time system, human intervention is not required.

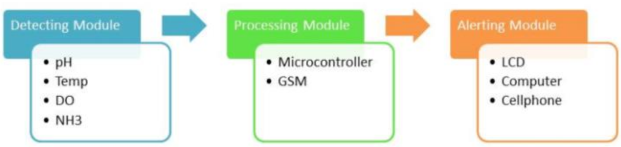

Figure-1. System framework.

Figure-2 illustrates the system flow of operation. Upon detection of the water parameters through different sensors, the data is processed in PIC16F4620 and Arduino. Then it is displayed to LCD and processed to GSM module so it can send data to cellphone and Personal computer or laptop. At this level, the aqua farmer or user was already alerted. In Figure-3, the perspective physical appearance of the device is shown. It consists of the display area of the measured data, the different inputs for the three (3) sensors, switch and GSM input.

Figure-2. System flow.

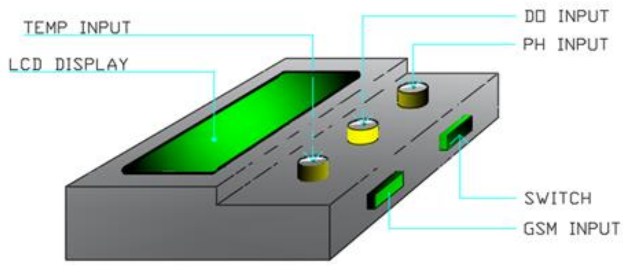

Figure-3. Perspective physical appearance of the device.

Data Processing

The device was designed with an SMS-based interface wherein farmers can automatically receive alert when the device monitors out-of-range values. It can send information to the user with respect to the grade of the water quality and also that of the status of the water. It was also equipped with an alert system using a computer or laptop. Once the water quality is not good, an alarm is activated for the nearby watcher to respond. All data were received and stored in the database. Furthermore, the system can print the information stored in the database.

Figure-4 shows the schematic diagram of the circuit simulated in *Proteuse* to ensure that the circuit functioned well.

System Evaluation

The developed device was evaluated with respect to its performance against with that of the standard device. Various samples of water were used to conduct the trials and tests. Moreover, the ability of the device to send alert and monitoring was also evaluated.

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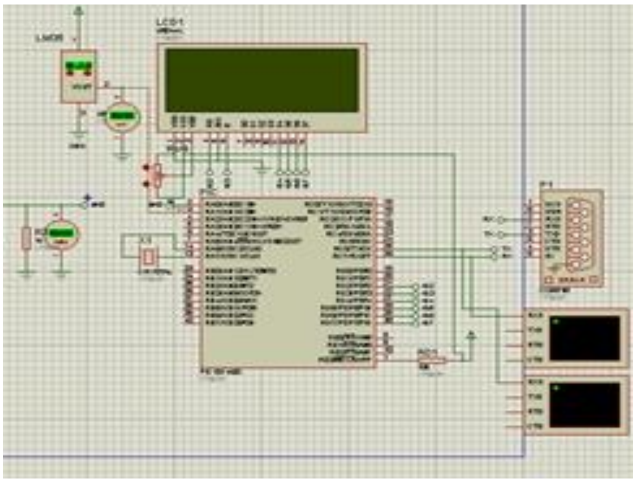

Figure-4. Schematic diagram of the circuit.

RESULTS AND DISCUSSIONS

System Development

The developed device was assembled consisting of different circuit boards embedded with different sensors and microcontrollers. Figure-5 shows the developed prototype device.

Figure-5. Prototype device.

The circuit was simulated or tested in *Proteuse* software to ensure that it functioned according to its purpose and displayed the necessary outputs. Debugging was also done in the software if adjustments were needed. Figure-6 shows the simulation output the system.

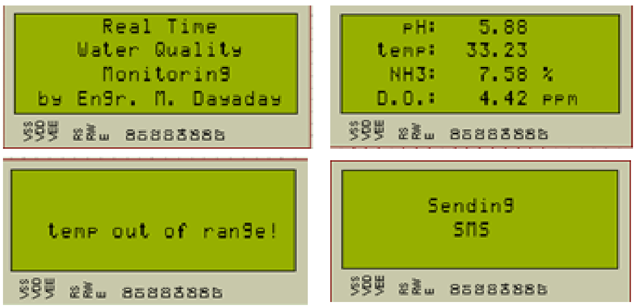

Figure-6. Simulation output of the system.

Data and Virtual Presentation

The data were received by the user/ farmer from the system. The user can access or monitor the water quality through SMS via cell phone (Figure-7(a)) and via LCD output display devices (Figure-7(b)).

(a) (b)

Figure-7. (a) Cellphone (b) LCD Output devices.

Laboratory Tests and Evaluation

The system was tested on laboratory scale. Figure-8 shows the comparative performance of the developed system/device with that of the standard device relative to the water quality parameters considered in the study. It can be observed that the developed device has almost the same performance with that of the standard device at various trials. Based on the gathered, the pH values have 97.61% accuracy with 2.39% mean error. On the other hand, the temperature values have an accuracy of 97.75% with a mean error of 2.25%. The DO value has93.67% accuracy with 6.33% mean error. Results show that the developed device functioned well according to its purpose with high degree of accuracy.

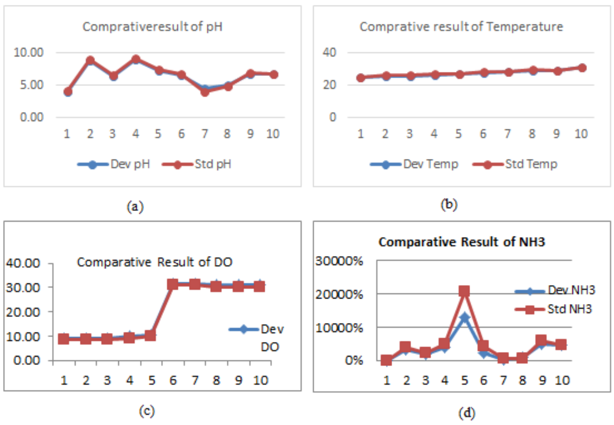

Figure-8. Comparative performance results of the proposed device with that of a standard device.

CONCLUSIONS

An innovative real time system water quality monitoring system for aquaculture application was designed and implemented utilizing probes and GSM network. The system was able to display the values of water quality parameters in the computer which sends alert to the user via SMS when the water is out range. Results of evaluation performance show that there were only minimal errors in the values of the parameters considered in the proposed device as compared with that of a standard device.

Hence, the system functioned according to its purpose with high degree of accuracy. The said device is a potential innovative solution to the problems encountered by small-scale aqua farmers.

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