Automated water quality monitoring system development via LabVIEW for aquaculture industry (Tilapia) in Malaysia

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ABSTRACT

Maintaining the quality of the water quality is one of the important aspects that play a substantial effect on the aquaculture industry especially in the tilapia industry. The quality of the water needs to be continuously monitored as any deviation from the allowed critical parameters such as water temperature and potential of hydrogen (pH) can cause unwanted scenarios such as disease, stress, higher mortality rate and profit loss. Currently, the monitoring process adopted by most fish breeders is done manually by using a portable sensor. This approach is found to be very tedious, ineffective use of manpower and time consuming particularly for the large-scale aquaculture industry. Hence, this research focuses on developing a simple, low-cost automated water quality monitoring system for the tilapia industry via LabVIEW software. The developed system will be able to monitor the parameter in real-time continuously with the capability of record and analyze each reading in a more efficient way. A data acquisition (DAQ) of NI myRIO-1900 is used as an interface between sensors and a monitoring station equipped with LabVIEW. Additionally, the developed system is equipped with an alarm system to alert the user when any deviation of the parameters occurs. Result shows that the system has a small range of average relative error of 4.28% and 6.22% for temperature and pH level respectively as compare to the portable sensor. Note that the errors are down to the selection of sensors. Furthermore, the developed prototype of the monitoring system has advantages in terms of its flexibility in extending the system with more sensors and allows a longer period of data collection without human intervention. The system is also upgradable with the integration of a control element to control the parameter when the monitored parameter is exceeded the threshold value. Succinctly, the system offers lots of advantages to the aquaculture industries with further improvement leads to better performance.

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1. INTRODUCTION

Malaysia has been recognized as a top 15 of global producers of aquaculture production [1]. Moreover, aquaculture industries in Malaysia play a significant role in the Malaysian national economy by supplying domestic and foreign demands of cheap protein food and by providing employment to the population [2, 3]. In ensuring the effectiveness and good profit return from this aquaculture industry, water quality has played a major factor particularly in the breeding process [4, 5]. The quality needs to be continuously monitored as any deviation from the allowed parameter/ measurement range can cause the unwanted scenario such as disease, stress, death and profit loss [6-9]. Different types of fish have a specific range of water quality level aspects such as temperature, potential of hydrogen (pH) level, dissolved oxygen (DO) concentration and other parameters. Maintaining a good quality of water is crucial for the fish industry particularly in the tilapia industry [10]. Prior studies show that the water quality can be achieved through microbial measurements as well as physiochemical measurements [11, 12]. Hypothetically, the amount of oxygen dissolved in water can be highly affected by the temperature of the water itself. Thus, critical parameters such as pH level and temperature of the water need to be monitored continuously to ensure the production of healthy fish.

Currently, in most of the aquaculture industries in Malaysia, the monitoring process of the quality of the water is carried out manually by using a portable sensor [13, 14]. Previously, the monitoring activity need to be done manually at the site and record it in a logbook [14]. Only trained and qualified personel can conduct the test and take measurements of water quality parameters [15]. This approach is found to be very tedious and time consuming (overall process to read and record the measurement will take almost half a day). Additionally, for a large-scale industry, this approach is very impractical with inefficient use of time management and manpower.

In order to improve the conventional method of monitoring process, an automated monitoring system is thought to be the best approach to cater those stated issues. Countries such as China, Taiwan and India have developed systems using sophisticated technologies to monitor the quality of the water [15, 16]. Different kind of topology has been adopted by many studies to develop an automated monitoring system [17-23].

Thus, this research aims to design and develop a low-cost automated water quality monitoring system specifically for the tilapia industry that able to perform the monitoring and recording of the water quality parameters automatically. The implementation of the developed system will help the industry to maximize the operation in terms of manpower and time management. The developed system will be able to not only monitor the parameter on-line (continuously), but also capable of recording and analysing each reading in a more efficient way

2. RESEARCH METHOD

The development of the monitoring system is divided into two section; system and hardware development.

2.1. System development

Water quality determines how well fish grow and whether or not to survive. Temperature and pH level have been chosen to be monitored in this system. These two parameters tend to change quickly and it can effect to the system if allowed to operate out-of-range [24]. Figure 1 depicts a block diagram of this system. Each tank is equipped with 2 sensors which measure the temperature and pH level of the water. These sensors are connected to a data acquisition system (DAQ), NI myRIO-1900 that is used as an interface to communicate between monitoring workstation (equipped with LabVIEW program) and sensors. With a built-in wi-fi feature in MyRIO, data received from sensors will be transferred to the monitoring workstation through a wi-fi connection. Figure 2 shows the layout of the overall system.

The developed system consists of two sensors (temperature and pH sensor) and DAQ NI myRIO-1900 from National Instrument. The NI myRIO-1900 offers a compact embedded device with analog input (AI), analog output (AO), digital input and output (DIO), audio, and energy output. The NI myRIO-1900 is connected via USB and 802.11b.g.n to a host.

LabVIEW software is used to program the system in order to allow the system to detect the signal and execute the task of monitoring by using the sensors that have been set up. Figure 3 shows the LabVIEW front panel for the system. LabVIEW can be understood easily and utilized by the user [6, 25]. The signal comes from each type of sensor are shown and displayed through this front panel. Figure 4 illustrates the LabVIEW block diagram panel. Standard range for water quality parameter set by fisheries research institute (FRI) Malaysia as shown in Table 1.

The minimum and maximum value of temperature and pH level are set based on the requirement from Fisheries Research Institute (FRI) Malaysia. The maximum value of the temperature is set to 32°C. When the value reaches 32°C the indicator will turn red. The relationship between temperature and DAQ system is given as follow:

$$\text{Temperature } (^\circ C) = Vout \times 100 \qquad (1)$$

Additionally, the pH is set to be in the range of 6.5 to 8.5 (based on standard range provided by Fisheries Research Institute (FRI) Malaysia). As the value of the pH reaches lower than 6.5 the indicator will turn into red colour.

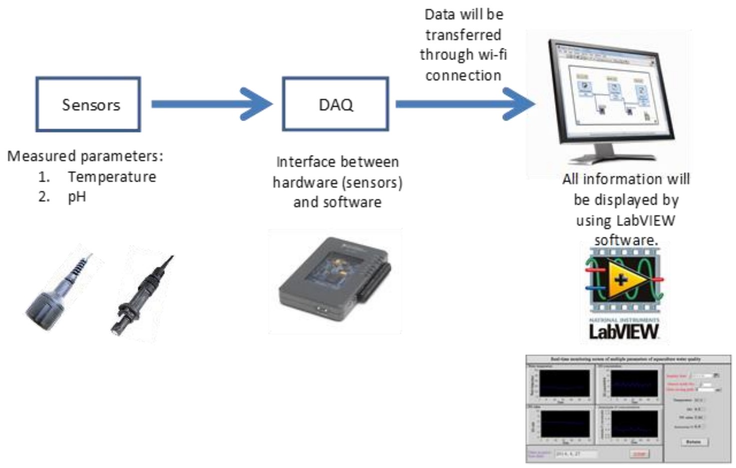

Figure 1. The block diagram of water quality monitoring system for the tilapia industry

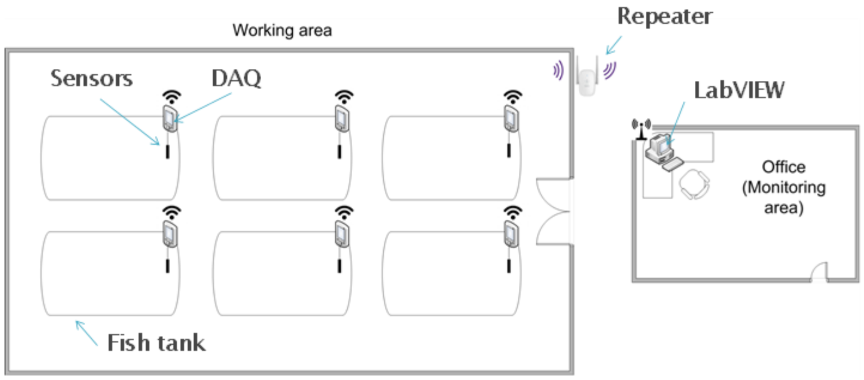

Figure 2. The layout water quality monitoring system for the tilapia industry

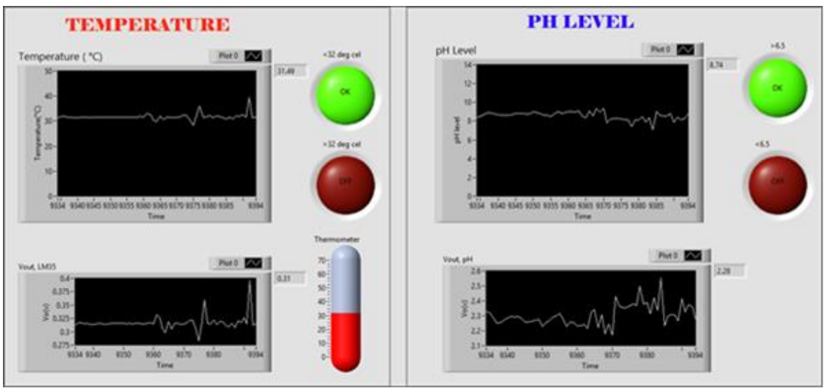

Figure 3. The front panel of the system via LabVIEW software

Table 1. Standard range for water quality parameter set by fisheries research institute (FRI) Malaysia

Parameter	Standard Ranges	Unit
Temperature	28 – 32	°C
DO	> 4	ppm
pH	6.5 – 8.5	
Salinity	24 - 32	ppt
Ammonia (NH3-N)	0.1 – 0.5	ppm
Nitrate (NO3)	0 – 10	ppm
Nitrite (NO2)	< 0.3	ppm

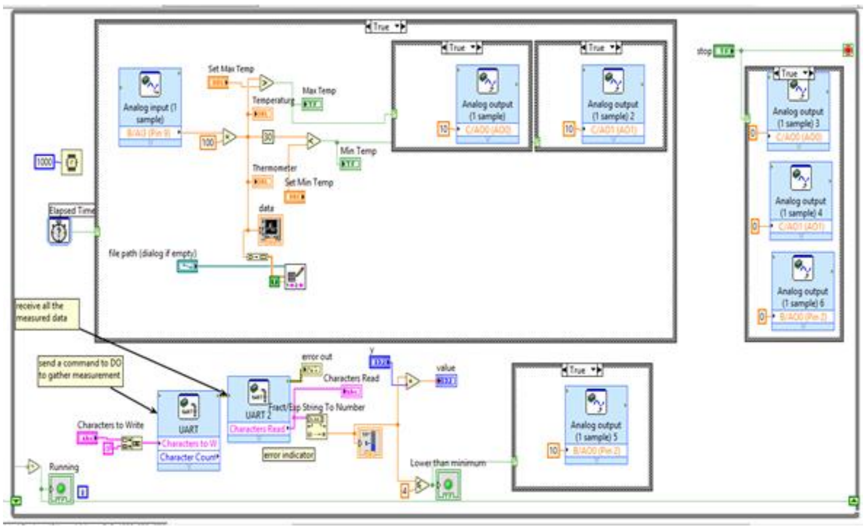

Figure 4. The block diagram of the system via LabVIEW software

2.2. Hardware development

The hardware development stage involves the circuit of pH that acts as signal conditioning. Figure 5 shows the connection of sensors, signal conditioning and data acquisition system. The modified temperature sensor, LM35 is directly connected to the analog input pin 9 on connector B of NI myRIO-1900 while the pH sensor is connected to pH probe BNC connector. The pH output terminal from the pH circuit is connected to analog input pin 5 connector A of NI myRIO.

LM35 is used as a temperature sensor while the pH sensor is the atlas scientific sensor. The pH circuit acts as signal conditioning while the NI myRIO-1900 device as data acquisition system and LabVIEW software as a monitoring system. The two sensors are constantly submersed into the water. Data gathered from sensors will pass through DAQ (NI myRIO-1900) system before being displayed and analysed in the LabVIEW. The data collected are being monitored through a monitoring station consists of LabVIEW programming. Figure 6 illustrate the experimental setup for automated monitoring system. Figure 7 shows the conventional set-up (manual process) versus the developed automated set-up.

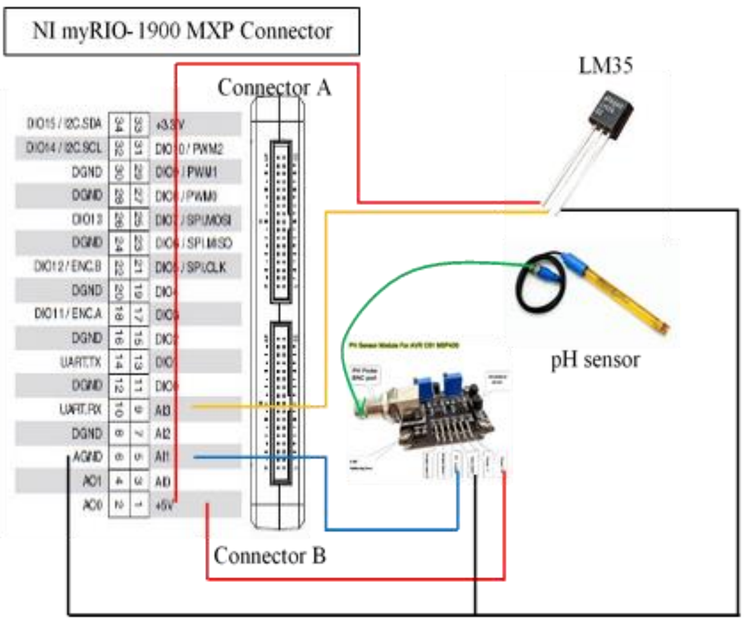

Figure 5. The hardware connection setup

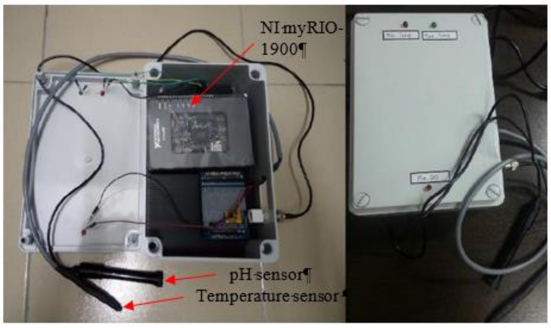

Figure 6. Experimental setup for automated monitoring system

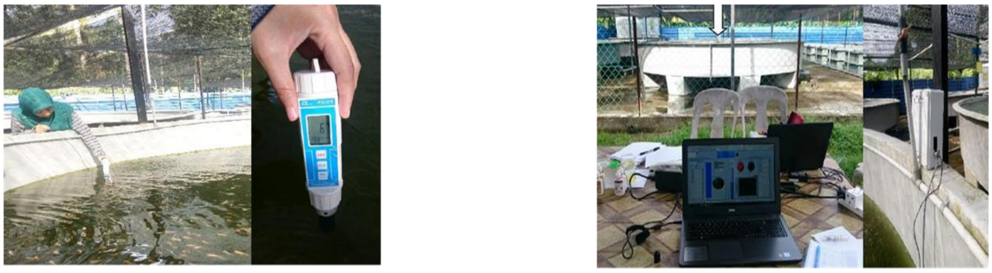

Figure 7. Manual set-up versus automated set-up

2.3. Data analysis

Two different set-ups have been deployed at the fish tank; manual system and automated system. Both systems are running simultaneously although the manual system takes longer time in gathering the data. The temperature and pH values are continuously gathered from the fish tank. Further analysis in determining the accuracy of the automated system is performed by calculating the percentage of error are stated as follow:

$$\%\,error = \left|\frac{Value_{automated} - Value_{manual}}{Value_{manual}}\right| \times 100 \tag{2}$$

3. RESULTS AND ANALYSIS

Figure 8 shows the front panel of temperature when the temperature of of water exceeds 32°C based on the system setup. By using the formula in (1), the temperature value during that time is 32°C. Hence, the LED will turn into red colour as an alarm indicator to alert the user that the temperature has arise.

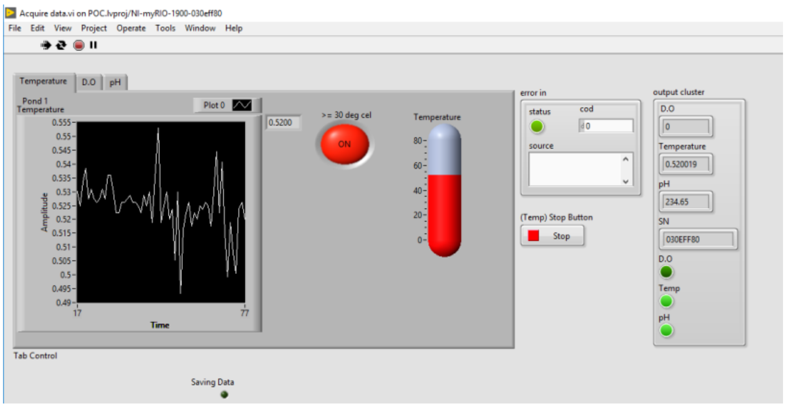

Figure 8. The front panel shows when the temperature exceeds 32°C.

Table 2 tabulates the accuracy of automated system by comparing the data gathered between these two set-ups (manual versus automated set-up). It shows that the percentage error between manual and automated measurements are less than 7% for the temperature parameter. These measurements proved that the developed automated system is able to measure correctly on those required parameters. Hence, it is proven that automated monitoring and data collection is suitable to be developed for thisaquaculture industries.

Table 2. The accuracy of temperature sensor of the system

No of data taken	Automated set-up (°C)	Manual set-up (°C)	Percentage of error (%)
1st	49.56	49.50	0.12
2nd	47.36	45.30	4.55
3rd	41.26	39.80	3.67
4th	36.50	34.20	6.73
5th	32.23	30.60	5.33
6th	29.17	27.70	5.31

The data of temperature and pH level of the water in tilapia tank were measured and collected. The readings of temperature and pH level of the natural water sample were taken for around 2 days. The reading was taken every 10 minutes for each parameter. Table 3 tabulates the readings of temperature and pH level. From the table, the relationship between the temperature and pH level can be seen. On 28 May 2019 at 6 pm, the value of pH level is 6.242 when the temperature at 31.738°C. This shows that at the highest temperature, the pH level is lower [19]. While on 28 May 2019 at 11.20 am, the value of the pH level is 6.702 when the temperature at 31°C. This shows that the lower temperature produces a higher value of pH level. Unfortunately, this condition can be seen on the first day only because the properties of the water sample start to change to acidic on the second day. This is because the value of temperature does not affect the properties of the water sample. Thus, on the first day, it can be concluded that the higher the temperature produces a lower pH level and vice versa. With this automated measurement, this system is able to guide and alert the user on the water quality of the tilapia industry.

Table 3. Table of temperature and pH level with time

Date/Time	Temperature(°C)	pH level
28/5/2019 8:00	31. 86	6. 47
28/5/2019 11:20	31. 01	6. 70
28/5/2019 14:40	31. 74	6. 29
28/5/2019 18:00	31. 74	6. 24
28/5/2019 21:20	31. 74	6. 34
29/5/2019 0:40	31. 74	6. 31
29/5/2019 4:00	31. 62	6. 63
29/5/2019 7:20	31. 37	6. 49
29/5/2019 10:40	30. 52	6. 39
29/5/2019 14:00	30. 27	6. 38
29/5/2019 17:20	29. 91	6. 29
29/5/2019 20:40	30. 52	6. 37

4. CONCLUSION

As a conclusion, this research is able to measure the water quality for tilapia industry based on two parameters, which are temperature and pH value. The system delivered a promising result with a significantly small percentage of error of less than 7% between automated and manual systems. In addition, this automated system is capable of constantly monitoring the water quality parameters within the desirable range suitable for aquaculture industry. The fish breeder will be alerted at the right time when the parameters go beyond the specified range. Thus, this shows that this low-cost system is able to deliver an accurate result that helps the fish breeder in monitoring the water quality automatically. For recommendation, this system can be improved by adding other parameters such as dissolved oxygen, turbudity and other parameters.

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