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Automated System of Water Quality Monitoring for Prawn Industry via Labview And Internet of Things

Nor Salwa Damanhuri[1] **Mohamad Haizan Othman[1]** **Nor Azlan Othman[1]***
Belinda Chong Chiew Meng[1] **Mohd Hanapiah Abdullah[1]** **Noor Azlina Mohd Salleh[2]**

[1] *Electrical Engineering Studies, Universiti Teknologi MARA, Cawangan Pulau Pinang, Permatang Pauh Campus, 13500 Pulau Pinang, Malaysia*
[2]*Smart Manufacturing Research Institute, School of Mechanical Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia*
* Corresponding author's Email: azlan253@uitm.edu.my

Abstract: Water quality is crucial to the health of the prawn industry in Malaysia, where unpredictable weather is common. However, many breeders still monitor the water quality manually, which limits their capacity to respond quickly to changing conditions. To address this, an automated system was developed using Internet of Things (IoT) technology to continually monitor and control the pH level and temperature of the saltwater. Sensors are connected to a LabVIEW-equipped data acquisition, and a servo motor operates the probe of the sensors. The proposed system employs ThingSpeak software to display real-time water quality data and has a system of alarms that can be activated to notify the user of any issues. An acid or alkali solution is pumped into the tank using a submersible water pump to regulate the pH level, and a fuzzy logic controller is integrated into the submersible water pump to control the valve for the solutions. From the results, the systems managed to measure the maximum value of the temperature which is 33.86°C meanwhile the minimum value is 30.6 °C. These temperature values are in the desirable range of temperature for prawn which is between 25 °C to 35 °C. Hence, this system depicts that the water is a good temperature for the prawn. Furthermore, the data transfer through wireless via ThingSpeaks' website is the same as the data transfer through mobile's app. Hence, this prove that the system is able to deliver the water quality data accurately and can be monitored remotely. The system will greatly benefit the aquaculture industry, and continued development will only improve its effectiveness.

Keywords: Aquaculture, Water quality, Data acquisition, LabVIEW, Internet of things.

1. Introduction

Prawn and other aquacultures play important roles in providing food chain to the human as source of protein. In aquaculture industry, water quality plays an important role in determining the health and the growth rate of the prawns [1, 2]. The important parameter such as potential of hydrogen (pH) and temperature need to be monitored and controlled to make sure the water quality is at optimum level [3]. According to the previous study, the optimum pH level for prawns' culture in marine water is in range 6-9 pH level which are below 5.0 or above 9.0 are totally lethal for prawns depends on the duration of exposure [4].

Currently, most breeders still use the traditional method that are lack capability for real time monitoring and fast dissemination of information for making any decision. That method has many disadvantages such as are impractical, higher cost of labour and highly subjected to error produce by humans. Furthermore, it is also lack in data information collection capability [5, 6].

There was a study that developed a ZigBee-based wireless sensor network of low-cost solar-powered air quality monitoring systems [7]. The wireless network sensor nodes are placed in the smart cities at different traffic signals that collect and report real-

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time data on various gasses present in the atmosphere and humidity. However, the data in this research only shown in the local area network rather than in the cloud.

Another study on wireless sensor networks for water quality monitoring was able to automatedly measure the water temperature, dissolve oxygen, pH, and electrical conductivity in real-time monitoring system [8]. The system includes of an Arduino microcontroller, sensors for water quality, and a module for wireless network communication. The data can be monitored in a web-based portal and mobile phone platforms in graphical and tabular format. However, this system is unable to control the sensors automatically.

Previous studies have shown many of automated systems that have been developed to monitor the water quality [3, 9-13]. However, these automated systems are not able to be applied in the saltwater environment as in prawn's ponds. This is due to the sensors that cannot withstand with the saltwater environment that could erode the sensors and reduce the durability of the sensors. Hence, there is a need to develop an automated system that is able to be used in saltwater environment for the water quality monitoring.

Thus, this research aims to develop a remotely automated water quality system for saltwater environment specifically for prawn industry remotely. This system is believed to able to measure, monitor and control the parameter of pH level and temperature of the saltwater for prawn's industry via internet of things (IoT) applications. The IoT system allows the system to be monitored remotely and display the water quality data in real time [14, 15]. By developing this automated water monitoring system, it will potentially help to maximise the operation and increase the productivity of the prawn's industry. This developed system is not only monitor the parameter in real-time remotely, but also capable of recording and analysing each reading in a more efficient way. Furthermore, this developed system is aims to increase the durability of the pH sensor and temperature sensor in the saltwater environment.

2. Methodology

2.1 System development

In this project, two of the important parameters of water quality for prawn's industry such as temperature and pH are measured using temperature sensor and pH sensor probe module respectively [16].

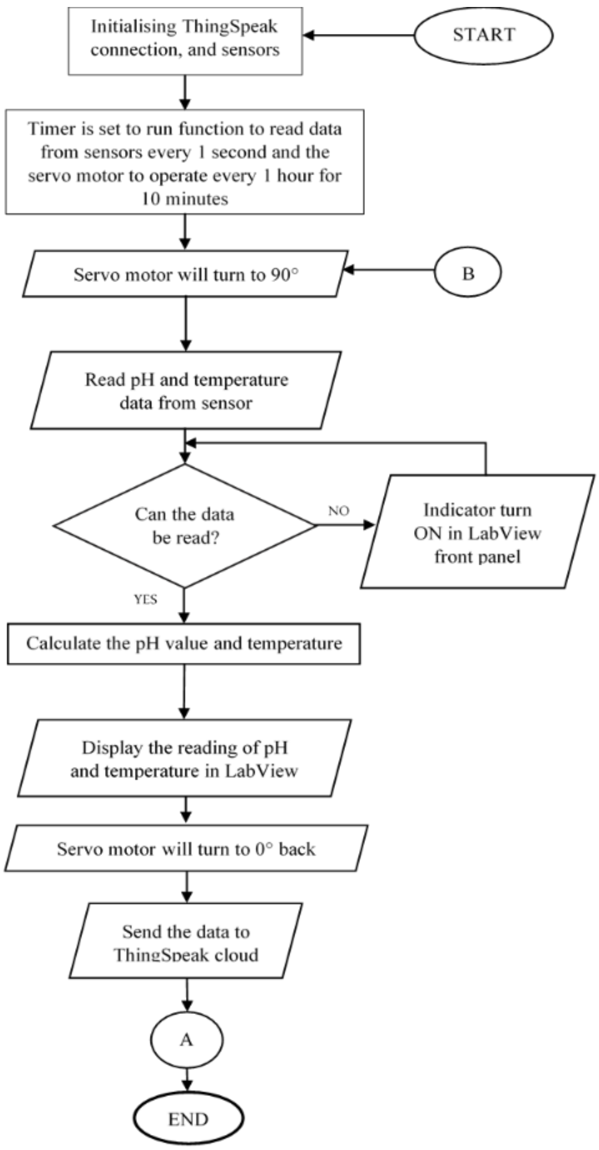
Table 1. Desirable ranges of water quality parameters and controlling actions taken

No.	Measured parameters	Unit	Desirable range		Measured values	Action taken
			Minimum value	Maximum value		
1	Temperature	Degree Celsius (°C)	20°C	35°C	<20°C and >35°C	Indicator will turn ON in LabVIEW front panel
2	pH	-	6.5	9	<6.5	Water pump for alkali is turn ON
					>9	Water pump for acid is turn ON

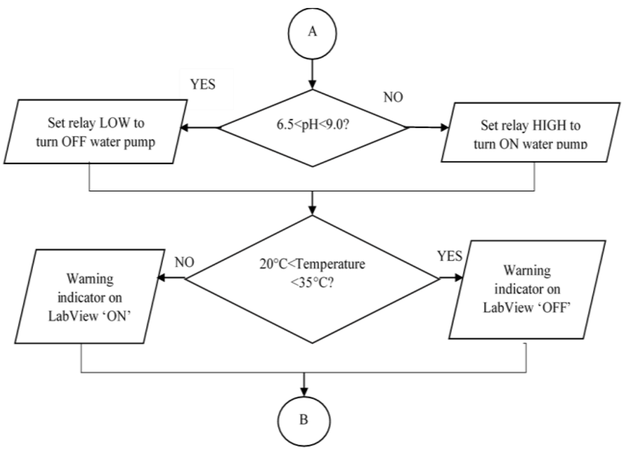
All the sensors are connected to the input of the data acquisition (DAQ) system which is NI MyRIO-1900 (national instrument's LabVIEW). The measurement system was installed at the pond and was powered up by solar PV system. At the output side of the DAQ, the controlling unit is connected which is the submersible water pump and servo motor using relay. The function of the relay is to turn ON or turn OFF of the controlling component if the water quality parameter is out of range compared to the desired range as shown in Table. 1. The function of the servo motor is to move all the sensors to be contacted with the saltwater for 10 minutes and pull its up back and rest for 50 minutes. This process was conducted every day from 8 am until 6 pm. This is to prevent the sensor from being corroded that can reduce the sensors' durability. The DAQ system has built-in processor, FPGA and Wi-Fi module.

The programming of the system through NI software which was LabVIEW 2016 to allow the automatic measuring and controlling the system from certain range [17]. The Wi-Fi module allows the breeder to communicate with the reading of all the sensor wirelessly. The data collected by the DAQ will then be transferred to the host computer to be displayed and monitor through LabVIEW software front panel in real-time. The IoT platform also will be used to analyses the data in graphical form which is ThingSpeak. The analyzed data can be view through mobile phone using ThingSpeak mobile app. The front panel in the LabVIEW will have indicator that will turn ON when the parameters are out of desired range and turn off when the parameter turn back to the optimum level. The block diagram of this system is depicted in Fig. 1.

Fig. 2 depicts the overview of the automated water monitoring system. The entire system was placed on the surface of the water at the point where the pH is likely to change and the temperature is higher than that at the outlet of the pond where the water is polluted by the prawn food [13]. The solar panel is attached as a power source to the DAQ system.



(a)



(b)

Figure. 1: (a) The flowchart of the system and (b) the continuation of the flowchart

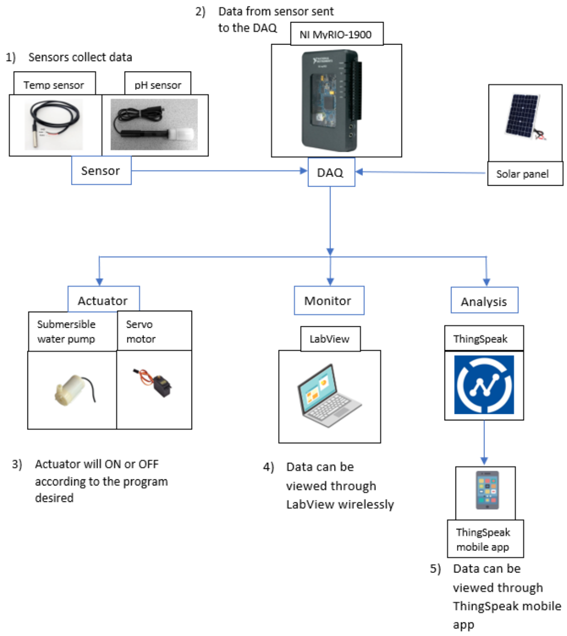


Figure. 2 Overview of the automated water monitoring system

2.2 Software design

As mentioned earlier, LabVIEW software is used as a GUI for this developed system. Both Figure. (a) and (b) show the LabVIEW front panel for temperature and pH sensor system [17]. For the sensors to be able to take data measurement, the servo motor must operate by 90 degree and it was indicated by the green rectangular box. ThingSpeak's application programming interface (API) key is the key to connect between LabVIEW and ThingSpeak's server.

As shown in Fig. 3 (a), the reading for both pH level and temperature are at optimum level where the temperature is normal, and the pH level is neutral. In contrast, if the temperature is high, a red indicator at the temperature reading will be turned on as shown in Fig. 4 (b). For pH level, the Alkaline' indicator was turned to the blue colour indicates that the water is alkaline.

This system used the fuzzy logic controller which controlling the valve and water pump of acidic and alkaline to maintain the pH level of the prawns' pond. It can be seen from Fig. 4 (b). That the water pump alkaline turn on and turn off at the specific time according to the quality of the water at that time whether it is acidic or alkaline. When the water is acidic, the water pump alkaline will turn on and when the water is alkaline, the water pump acidic will turn on. Hence, this automated monitoring system allow to control the water quality of the system automatically.

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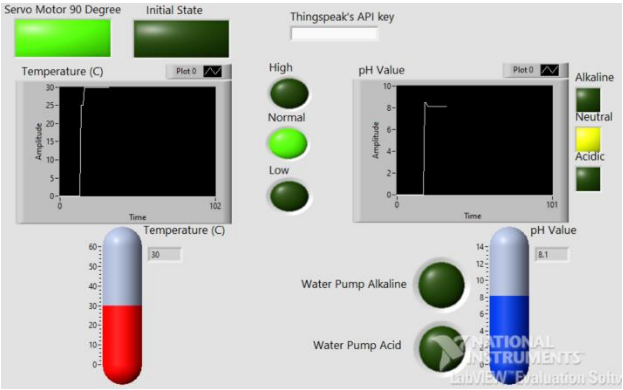

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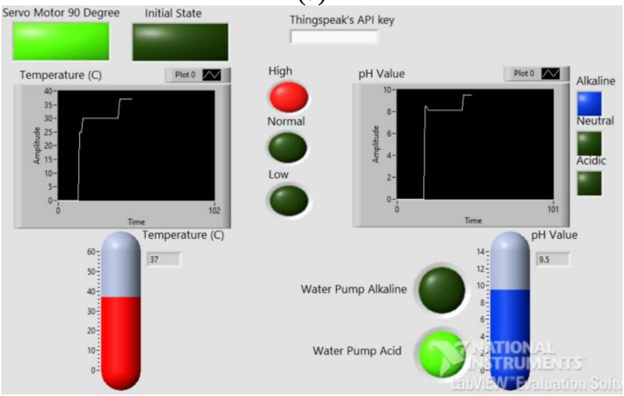
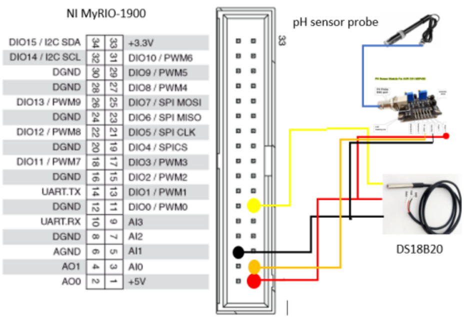


(b)

Figure. 3: (a) Front panel of LabVIEW when parameters are optimum and (b) Front panel of LabVIEW when parameters are not optimum



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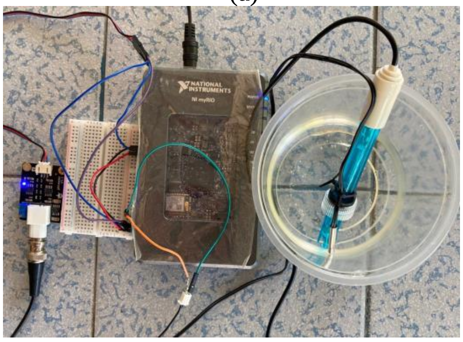

(b)

Figure. 4: (a) Hardware connection setup for the system and (b) Experimental setup for the system

Table 2. Membership functions of the fuzzy logic controller for the water pump

Water pump / Rules	Acidic water pump	Alkaline water pump
pH < 6.5	0	1
6.5 < pH < 9	0	0
pH > 9	1	0

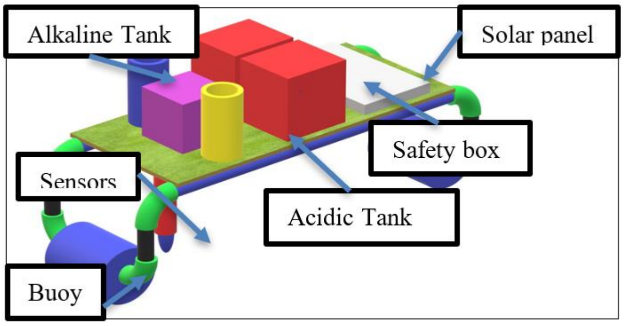

Figure. 5 The prototype of the automated water monitoring system

Table shows the membership function of the fuzzy logic controller. There are three types of rules that was set in the fuzzy logic which are when pH is below 6.5, pH between 6.5 and 9, pH more than 9. When pH below 6.5, acidic water pump will off while alkaline water pump turns on. When the pH in between range 6.5 and 9, both water pump will turn off and when pH more than 9, alkaline water pump will off while acidic water pump will turn on.

2.3 Hardware design

Fig. 4 shows the hardware design consists of pH circuit which acts as a signal conditioning. There is also the temperature sensor which is NTC 3950 that is waterproof. The pH probe is connected to the pH module and act as an input into pin A/AI0 at NI MyRIO-1900. The temperature sensor is directly connected to the pin A/DIO0 at the DAQ. The sensors are dipped into the water at certain time by the servo motor and bring it up back to avoid from corrosion. For pH value, the pH probe will collect the data of the water and sent to the pH module that act as a signal conditioning. The signal then will be amplified and sent to the DAQ. Different from temperature sensor that collect data and directly sent it into the DAQ. Then the data will be processed by the DAQ and will sent the data to the host computer at the base station.

Fig. 5 shows the prototype design for the water quality monitoring system. The solar panel acts as the power source for the whole system since the system was implemented in the middle of pond which is quite far from land. The DAQ was places inside the

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safe box for the durability of the system. The buoy will help to float the whole system in the pond. The sensors were connected with the servo motor at the bottom of the system. The servo motor acts as the controller to control the sensor when to dip inside the water and when to bring it out of the water. This will increase the durability of the sensors.

2.4 Data analysis

The data from temperature and pH sensor were collected continuously for one day and for a week. The connection time between the data gathered from the sensor until it was upload into ThingSpeak. The data will be collected both temperature and pH sensor continuously from 8 am until 6 pm. Within this time period, two internet connection type will be used:

1. Internet connection through wireless from mobile hotspot
2. Using mobile phone itself to monitor the data through ThingSpeak's mobile apps.

Using the data gathered in ThingSpeak and mobile's app within the time period, the input time were compared, and the percentage differences had been calculated. Using the value, the performance of the sensors using wireless and using mobile's app was determined as shown in Eq. (1).

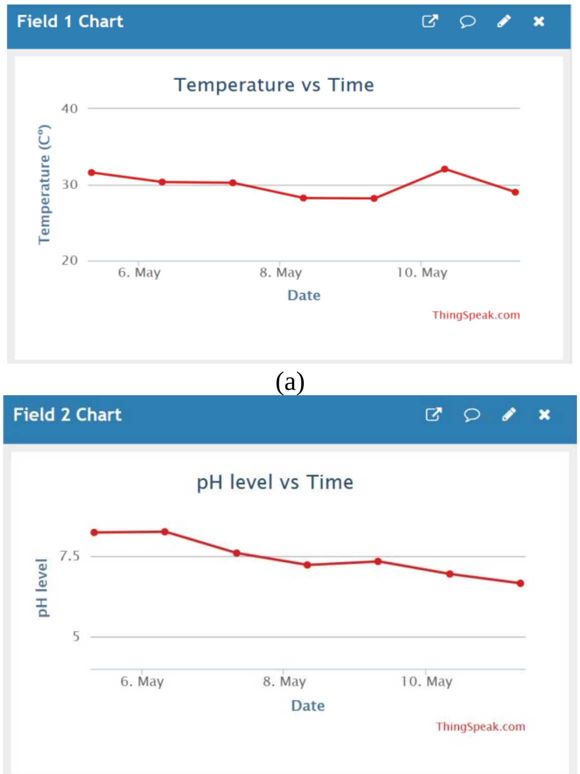
$$Percentage\ Different = \frac{|V_1 - V_2|}{[\frac{(V_1+V_2)}{2}]}\ x\ 100 \quad (1)$$

Where,
V_1=Final Value
V_2=Initial value

3. Results and discussion

This proof-of-concept system was operated continuously, and the results were collected from 8 am until 6 pm for one week at each of the day. Fig. 6 (a) and (b) show the graph from ThingSpeak's server for the result of data collection for a week using wireless internet connection. This data can be captured using the mobile phone. It delivers the accurate real-time results and help to monitor the water quality of the prawn's pond remotely.

Fig. 7 shows the relationship between temperature and pH level vs time for one week. It can be seen that the temperature result did not give much effect to the changes of pH level. Fig. 8 shows the graph for the result of data collection for one day using wireless internet connection. The data were presented for every 30 minutes from 8 am until 6 pm.



(b)

Figure. 6: (a) Graph temperature vs time and (b) Graph pH level vs time captured using ThingSpeak

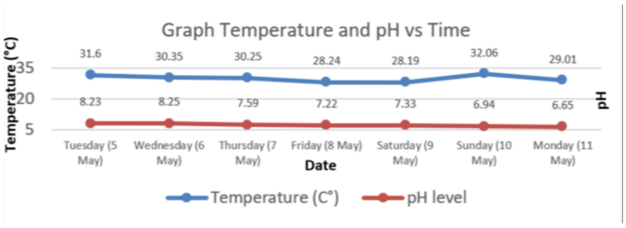


Figure. 7 The graph of relationship between temperature and pH level vs Time

As can be seen in Fig. 8, during morning, the temperature is lower as compared to the afternoon and it start to rise because of outer surrounding and falls back in the evening. This is because of the outer surrounding that effect the temperature of saltwater.

As for the pH value, it depends on the quality of the water and the rainwater. As shown in Fig. 6 (b), the pH level keeps decreasing days by days. This means that the acidity of the water has increase due to many factors. One of the factors is due to the impurities in the surrounding air. Another factor that affects the pH level is the rainwater. As can be seen in Fig. 7 , at 8th of May, the level of the pH value dropped due to the heavy rain during that day. According to previous study [15], the normal mean pH value for rainwater is 5.91±0.49. Hence, the results proved that the rainfall appears to be slightly acidic in nature.

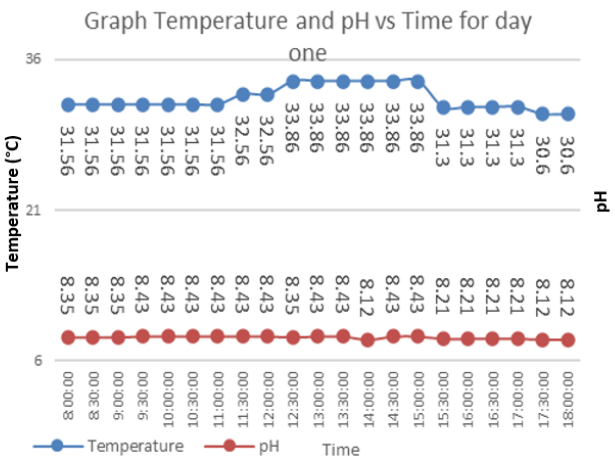


Figure. 8 Results of temperature and pH level for one day

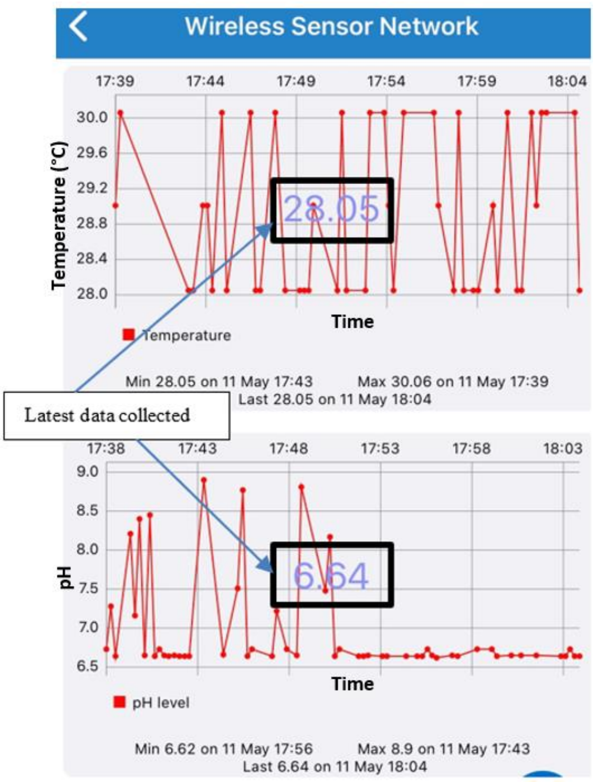


Figure. 9 Graph for latest data collection using ThingSpeak's mobile apps

Furthermore, it can be seen that the maximum value for temperature is 33.86°C meanwhile the minimum value is 30.6 °C. Based on Table which is the desirable range value, the desirable temperature for prawn is between 25 °C to 35 °C. Hence, this system depicts that the water is a good temperature for the prawn.

In contrast, the maximum and minimum pH level for the system was measured as of 8.43 and 8.12 respectively. This shows the results are within the desirable pH value for prawn.

Table 3. The result of input time between wireless and mobile's app

Parameters		Input time		
Temperature (°C)	pH level	Mobile's app	Wireless (monitoring station)	% difference
28.05	6.64	5:54:39 PM	5:54:39 PM	0
30.06	6.64	5:55:13 PM	5:55:13 PM	0
30.06	6.64	5:56:53 PM	5:56:53 PM	0
29.01	6.64	5:57:08 PM	5:57:08 PM	0
28.05	6.64	5:57:59 PM	5:57:59 PM	0
30.06	6.73	5:58:15 PM	5:58:15 PM	0
28.05	6.65	5:58:32 PM	5:58:32 PM	0
28.05	6.62	5:59:04 PM	5:59:04 PM	0
28.05	6.65	5:59:20 PM	5:59:20 PM	0
29.01	6.64	6:00:09 PM	6:00:09 PM	0
28.05	6.73	6:00:24 PM	6:00:24 PM	0
30.06	6.73	6:00:57 PM	6:00:57 PM	0
28.05	6.64	6:01:29 PM	6:01:29 PM	0
28.05	6.65	6:01:44 PM	6:01:44 PM	0
30.06	6.65	6:02:17 PM	6:02:17 PM	0
29.01	6.65	6:02:33 PM	6:02:33 PM	0
30.06	6.64	6:02:50 PM	6:02:50 PM	0
30.06	6.64	6:03:06 PM	6:03:06 PM	0
30.06	6.73	6:04:40 PM	6:04:40 PM	0
28.05	6.64	6:04:56 PM	6:04:56 PM	0

Fig. 9 shows the result of data by using the ThingSpeak's mobile apps which is Thingview. Based on the Fig. 9, the data collection for both temperature and pH level delivers more detail as compared to the websites as it shows the minimum and maximum value for the result. It also shows the day, date and time for that specific data.

All the collected data will be stored in the Google drive and can be access anytime. In this project, 20 data was collected and had been compared between wireless connection and mobile's app as tabulated in Table 3. The data transfer through wireless via ThingSpeaks' website is the same as the data transfer through mobile's app. Hence, this prove that the system is able to deliver the water quality data accurately and can be monitored remotely. This will save time, cost of travelling and labour cost. Furthermore, this automated system is able to alert the user on the condition of the water and also able to control the pH level of the water by using the fuzzy logic controller as mentioned earlier. Thus, this automated water quality monitoring system is able to be commercialised and potentially be used for prawn industry worldwide.

4. Conclusion

In this research, an automated water quality monitoring via IOT for prawn industry has been developed. This system is able to control the pH value of the water by adding alkaline or acid to neutral the saltwater by using the controller that developed via the LabVIEW software. The monitored water parameters are temperature and pH level. The systems is succesfully measure temperature with a maximum value of the temperature is 33.86°C and the minimum temperature is 30.6 °C. These temperature values are in the desirable range of temperature for prawn which is between 25 °C to 35 °C. Furthermore, the speed of the data transmission which is the performance of this system from the sensor to the LabVIEW and to ThingSpeak's server was observed and the result shows that the speed is the same with 0% differences. Hence, this prove that the system is able to deliver the water quality data accurately and can be monitored remotely via the IoT. This system also allows the user to be alert on the changes of the pH level and temperature of the water. Hence, this system is able to save time and labour cost. For recommendation, this system can be further improved by adding other parameters to measure such as dissolved oxygen and turbidity.

Conflicts of interest

The authors declare no conflict of interest.

Author contribution

"Conceptualization, Nor Salwa Damanhuri and Mohamad Haizan Othman; overall analysis, data collection and original draft writing, Nor Salwa Damanhuri and Mohamad Haizan Othman; overall concept, methodology, review and editing, Nor Azlan Othman; data analysis, review and editing, Belinda Chong Chiew Meng and Mohd Hanapiah Abdullah; review and editing, Noor Azlina Mohd Salleh."

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