International Journal on Advanced Science Engineering Information Technology

Vol.11 (2021) No. 4
ISSN: 2088-5334

Smart System and Monitoring of *Vanammei* Shrimp Ponds

Vivien Arief Wardhany[a,*], Herman Yuliandoko[a], Subono[a], M. Udin Harun A[b], I Gede Puja Astawa[b]

[a] *Informatics Engineering, Politeknik Negeri Banyuwangi, Banyuwangi, East Java, 68462, Indonesia*
[b] *Informatics and Computer Engineering, Electronic Engineering Polytechnic Institute of Surabaya, Surabaya, East Java, 60111, Indonesia*
Corresponding author: [*]vivien.wardhany@poliwangi.ac.id

***Abstract*— Aquaculture has become one of the livelihoods for people who live near the shore. Fish, shrimp, and crabs are cultivated using the traditional method, which still involves workers checking the *vanammei* shrimp pond's condition directly on site. We present a new technology for fish farming by using automation. An automation system is needed to control the system remotely so that the farmers can easily access the Water temperature, pH, and Salinity information. The proposed system consists of several parts; the first one is the sensors connected to the Arduino board, which is already equipped with the *WeMos D1* mini-module (*ESP8266EX)*. The module can connect the Arduino board to the web server and then transmit the data obtained from reading the temperature, pH, and Salinity sensors. Furthermore, the data will be stored on the webserver and processed and presented in graphical form—each sensor (pH, Salinity, Temperature) working based on the fuzzy logic rule. An android application also create to display the water condition of each shrimp pond. The Android application provides the reporting of daily monitoring of the pH, Salinity, and Temperature. The application also provides the control system to turn on/off the smart system; if the water condition is experiencing changes, the app will send a notification into the Smartphone. The weather changes have an impact on the success level of *vannamei* shrimp cultivation. Continuous rain conditions can adversely affect ponds' pH water conditions, temperature changes occurring pond water, changes in salinity and acidity, and hardness of the ponds water. Using a mobile application to monitor all parameters related will improve fish and shrimp cultivation.**

***Keywords*— *Vanammei* shrimp; pH; salinity; temperature; fuzzy logic; Arduino. Android application.**

Manuscript received 11 Apr. 2019; revised 26 Dec. 2019; accepted 22 Jan. 2020. Date of publication 31 Aug. 2021.

I. INTRODUCTION

American White Shrimp (*Litopenaeus vannnamei*) is one of the types of shrimp that can be cultivated in Indonesia, besides tiger shrimp (*Litopenaeus monodon Fab*). In Indonesia, *Litopenaeus vannamei* is widely known as *vaname shrimp* [1]. This type of shrimp have superiority among the others for shrimp farming activities in ponds, they're responsive to feed, resistant to disease attacks even in the poor environmental quality, faster growth, high survival rate, high stocking density, and relatively short maintenance time which is around 90-100 days per cycle [1]–[3]. Aquaculture has become one of the main livelihoods for the people near the shore, especially in the Banyuwangi region. The cultivation used by the local people is still in traditional cultivation methods, using simple equipment, and must be manually checked sometimes to see the condition of the ponds.

The method will certainly impact the maintenance cost of the ponds because they need to pay workers to monetarize and control the shrimp ponds to keep the ponds in good condition. An automation system is needed to control the system remotely so that the farmers can easily access the Water temperature, pH, and salinity information [4], [5]. Weather changes have an impact on the success of *vannamei* shrimp cultivation. Continuous rain conditions can adversely affect pond water conditions, temperature changes occur in pond water, changes in salinity and acidity, and hardness of pond water. If it happens, the physiological conditions of the shrimp will be disrupted, making it susceptible to disease. In addition, low temperatures accompanied by high waste concentrations can cause increased sources of disease for shrimp [5].

In Banyuwangi, ponds are mostly owned by local residents. They managed the ponds by conventional, intensive and semi-intensive cultivation. For example, *vaname* shrimp ponds in the Karangrejo area Banyuwangi Regency are traditionally checked manually by paying the guard to monitor the ponds that are carried out continuously. This problem increases the cost of farming and a lot of energy and time needed to maintain the health of *vaname* shrimp pond water at all times.

Monitoring of *Vanammei* shrimp ponds offering the easy way out to use the automatic control system by an application so that the farmer can access information of Water temperature, pH, and salinity easily and efficiently by using an android application [3], [6].

II. Materials And Method

In Aquaculture, water quality affected the shrimp or the fish production in terms of size and number. Water quality is the most important aspect of shrimp production. Another aspect should also be considered important to maintain high-quality water, such as PH, temperature and Salinity, Total nitrogen and water hardness. These aspects are influenced not only by each other but also by other factors, such as the surrounding environment [5].

TABLE I
WATER QUALITY CRITERIA

Parameter	Water Parameter	Technology Level			
		Simple	Semi-Intensive	Intensive	Super intensive
Temperature	C	28-32	28-30	28-30	28-30
Salinity	g/l	5-40	10-35	26-32	26-32
pH	-	7.5–8.5	7.5–8.5	7.5–8.5	7.5–8.5

Therefore, water quality management during the maintenance process is necessary. The basic parameters of water according to general guidelines from the Indonesian government are in table 1.

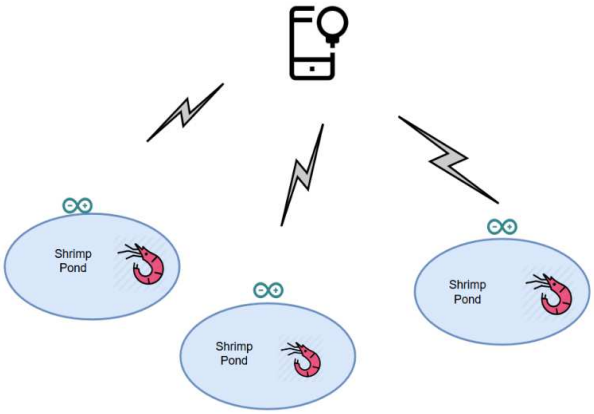

Fig. 1 The Proposed System

The proposed system made consists of several important parts. The first part is the sensors that are connected to the Arduino board, where on the Arduino board is added a *WeMos D1* mini-module (ESP8266EX). It connects the Arduino board to the web server and then transmits the data obtained from reading the temperature, pH, and Salinity sensors. Then the data was stored on the webserver; then, the data was processed and presented in the graphical form [7].

A. Hardware Design

In this system, if the value of temperature, pH, and salinity are quickly changing, it was followed by the action to stabilize the environment of the ponds. The actions to stabilize the environment used several devices are Paddle Wheel and water pump. The chemical reaction runs using the calcium powder to stabilize the pH using the paddlewheel and Water Pump to circulate the water through the ponds.

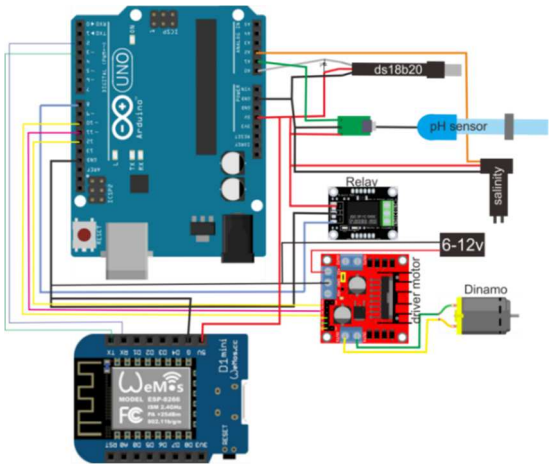

Fig. 2 Hardware Design

Several devices in the system like temperature sensor, pH sensor, and Salinity sensor works based on the fuzzy rule. It runs automatically and is controlled by using a Smartphone application. The hardware design is arranged in Figure 2. The function of each part is explained as follows:

1) Arduiono Uno R3: The Arduino Uno R3 is a series of microcontroller boards based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. The *Arduino* module has 20 digital input/output pins (6 as PWM outputs and 6 pins as analog inputs). The *Arduino* also has an extensive support community, making it easier to work with other embedded electronics. In this research, we use the *Arduino Uno r3* board as the main system on hardware.[7]–[9].

2) Wemos D1 mini: *Wemos d1* mini, is a development board module based on WiFi that aims to send sensor data to the Web server. In order to connect with *Arduino*, *Wemos d1* mini requires connection of *rx* and *tx*, and 5v voltage. Wemos is one of the *Arduino* compatible development boards specifically designed for IoT (Internet of Thing) purposes. *Wemos* use a well-known WiFi chip, ESP8266. *Wemos* has several advantages that are suitable for IoT applications. It can be connected to microcontroller devices such as Arduino with the internet via using a WiFi module. We used the *WeMos D1* mini as boards to connect the hardware system (sending the data from each sensor) to the webserver [10].

3) Sensors Component: This system uses the temperature sensor, the pH sensor, and the salinity sensor [2], [11]. Each sensor has its function. The temperature sensor is used to get the value of the temperature of the water on the ponds. The temperature sensor is connected to *Arduino* boards by using the red cable (for 3,3-5,5 v), the black one is for grounding (GND), and the grey is for data connection connected on A0 pin. It requires a 1-wire library and Dallas temperature to connect *Arduino* to set the program's script. If the temperature exceeds the normal value, the system will turn on the paddle and perform oxygen distribution, so there will be no dead spots in the pond. The other function is to stabilize the temperature inside the pond. Additional water is performed to

maintain the pond's height, while water alteration is performed to maintain water quality.

4) Web Server: A web server is a system that delivers content or services to end-users over the internet via HTTP service. The data (Temperature, PH, and salinity) will be transferred from the sensor using the *Wemos* module to My SQL database server. The data was processed and displayed to the webserver. In this system, the webserver stores data from the sensors and displays the monitoring data.

B. Fuzzy Logic

The fuzzification stage sets up the design of the fuzzy set by check the temperature and the pH setting. The next stage of inference is the determinant of decision-making. The last stage is defuzzification is the process of determining the output that affects the condition of the mill. The fuzzification stage is the initial stage of the formation of the fuzzy logic method. This stage provides a graph of membership function established in implementing fuzzy pumps and water Spools of shrimp ponds [12], [13].

1) Water Wheel Fuzzification: The membership function of the temperature sensor has three conditions: cold temperature, normal temperature, and hot temperature. The following is the design of the temperature fuzzification set In Figure 3.

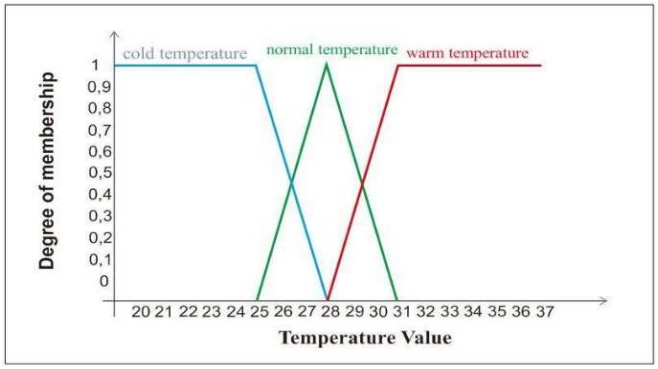

Fig. 3 Membership of the Temperature Function

The pH sensor membership function has three conditions: acid, neutral and alkaline. Low pH condition due to high levels of CO_2 from the process of organisms, as shown in Figure 4.

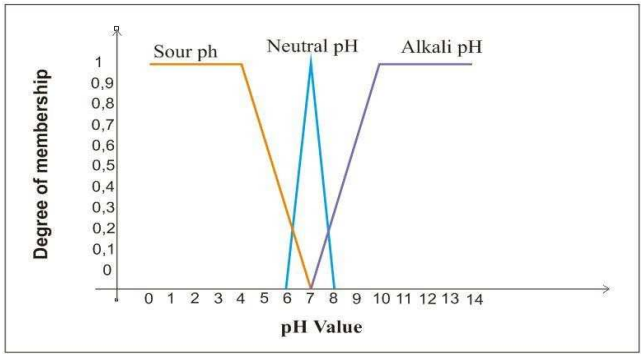

Fig 4. Membership of pH Function

Then the pinSpool is required to stabilize the pH value. In addition, the installation of the mill is adjusted on a pond made for the circulation/distribution of oxygen to be uniform (in addition, no dead point). In the fuzzy process needs to be made some rules called rules. The rule contains how many conditions that may occur along with the reaction of the condition. The rules used in this system are listed in Table 2.

TABLE II
PIN SPOOL RULE

Rule Number	Pin Spool Rule		
	Temperature	*pH*	*Pin Spool*
Rule 0	≤ 24 ^{0}C	6.5 – 8.5	ON
Rule 1	25^0 – 31 ^{0}C	6.5 – 8.5	OFF
Rule 2	≥ 32 ^{0}C	6.5 – 8.5	ON
Rule 3	≤ 24 ^{0}C	< 6.5	ON
Rule 4	25^0 – 31 ^{0}C	< 6.5	ON
Rule 5	≥ 32 ^{0}C	< 6.5	ON

2) Water pump Fuzzification: The membership of salinity sensor function has three conditions: normal, brackish, and salted. The following is the design of the temperature fuzzification set in Figure 5.

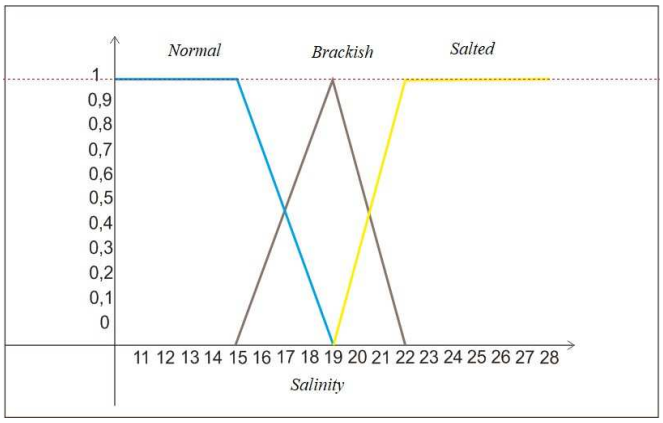

Fig 5. Membership of Salinity Function

In the fuzzy process needs to be made some regulation called rules. The rule contains how many conditions that may occur along with the reaction of the condition. The rules used in this system are listed in Table 3.

TABLE III
SALINITY RULE

Rule Number	Salinity Rule		
	Salinity	*pH*	*Water Pump*
Rule 0	> 22 ppt	< 8.5	ON
Rule 1	> 22 ppt	6.5 – 8.5	ON
Rule 2	15 – 22 ppt	< 8.5	ON
Rule 3	15 – 22 ppt	6.5 – 8.5	OFF

Fuzzy logic control is very useful when the dynamics system is not recognized, as temperature values change or normal pH temperature is abnormal and vice versa [12], [14]. Fuzzy logic as a determinant of decision making for the condition of waterSpool and water pumps.

III. Result and Discussion

The temperature control system, ph, and salinity devices that have been created is a prototype used to control temperature imbalance, ph, and salinity in Vanammei shrimp Ponds. From each sensor, we can get the value of water temperature, pH, and salinity then the information from each sensor will be saved on the webserver. A web server is a system that delivers content or services to end-users over the internet. The transfer data is to transfer data (Temperatur, PH & salinity) from the sensor using *Wemos* module to My SQL database server. The data was processed and displayed to the webserver. We used the webserver to store the data from the sensors and display the monitoring data on this system. An Android app is a software application running on the Android platform [15]. In this research, we build the android app to control the power of the Hardware system. Then, the monitoring data was reported from the sensors; the graph of the data monitoring was also presented.

A. Error Rate of the Sensors

The accuracy of each sensor was tested with several test items; the test result reflected how accurate the sensor. Accuracy is how close a sensor shows the value to the actual value. The accuracy is shown by the accurate value, as presented by the graph of error rate from each sensor.

$$Error\ rate = \left|\frac{Value\ (experimental) - Value(theoritical)}{Value(theoritical)}\right| \text{ x } 100\%$$

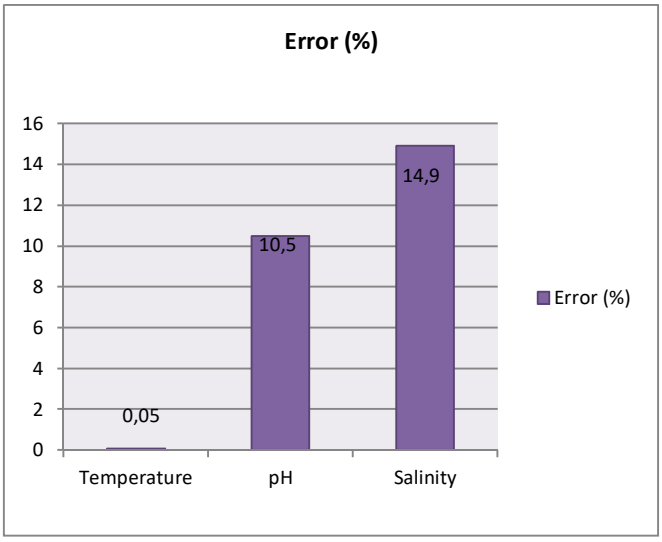

Fig. 6 Error rate on each sensor

WeMos D1 mini-module is first connecting the *wemos* module with a micro USB cable to the PC. Open cmd on a PC connected to the internet, see the IP address by typing *ipconfig* on *cmd*. The Data transmission Testing uses the *D1* mini *Wemos* module that has been programmed before; to the hardware and web server are connected, we must run the program on Arduino Uno, and the data generated by each sensor is sent to the database and then displayed on the webserver. Data measurement of water condition on the shrimp ponds during March to July 2018:

TABLE IV
Data Measurement on The Shrimp Ponds

Time: 05.00 am					
	March	April	May	June	July
			2018		
-- pH	7	9	7	6,5	9
-- Salinity	30 ppt	34 ppt	24 ppt	30 ppt	34 ppt
-- Temperature	28 C	28 c	24 c	25 c	28 c
Weather	Sunny	Rainy	Sunny	Sunny	Rainy
Time: 12.00 pm					
	March	April	May	June	July
			2018		
-- pH	7	9	7	6,5	9
-- Salinity	36 ppt	40 ppt	27 ppt	36 ppt	40 ppt
-- Temperature	30 c	28,8 c	28 c	30 c	28,8 c
Weather	Sunny	Heavy Rain	Sunny	Sunny	Rainy
Time : 07.00 pm					
	March	April	May	June	July
			2018		
-- pH	7	9	7	6,5	9
-- Salinity	20 ppt	33 ppt	24 ppt	20 ppt	20 ppt
-- Temperature	24 c	27 c	24 c	23 c	27 c
Weather	Clear	Clear	Clear	Clear	Clear

The data measurement shows that the value of pH, Salinity, and Temperature have each unique value. Except for PH Graph, it shows the same pH Value on each time measurement.

From the graph figure of water pH, the max value of pH is 9; this condition is very dangerous to the shrimp. From graph figure 10 and 11, we can see that the value of salinity rises to 40 ppt in April and July, that is the abnormal condition and can causing harm to the shrimp, according to the max value of water salinity from the standard is 35 for semi-intensive ponds. In April and July, when the data are taken, the weather is heavy rain, and this condition is suspected of increasing the value of water salinity on the shrimp ponds. As display by the temperature data measurement, we can see that the maximum temperature value of the temperatures is 30°C. Moreover, the max temperature occurs in March and June on the dry.

B. Android Application

This application aims to perform monitoring using a Smartphone device with an Android OS based [16]. This android application is carried out monitoring using the Monitor feature containing the name of the ponds, pH, Temperature, salinity, Date of Measurement, and the time of Measurement. The Report feature contains a Pdf download data documents, a graphical feature, and a monitoring history feature, and the key feature is Control with an On / Off button.

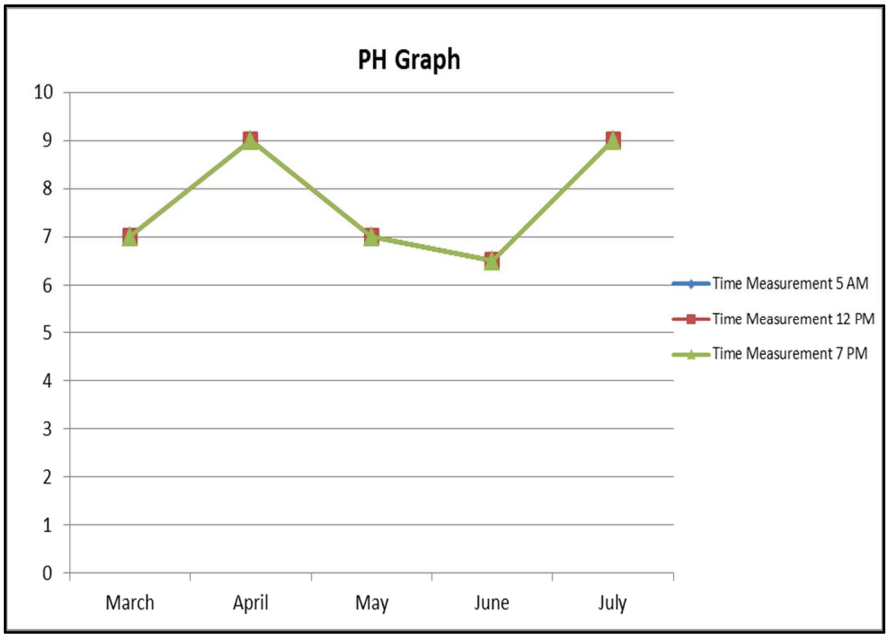

Fig. 7 pH Graph

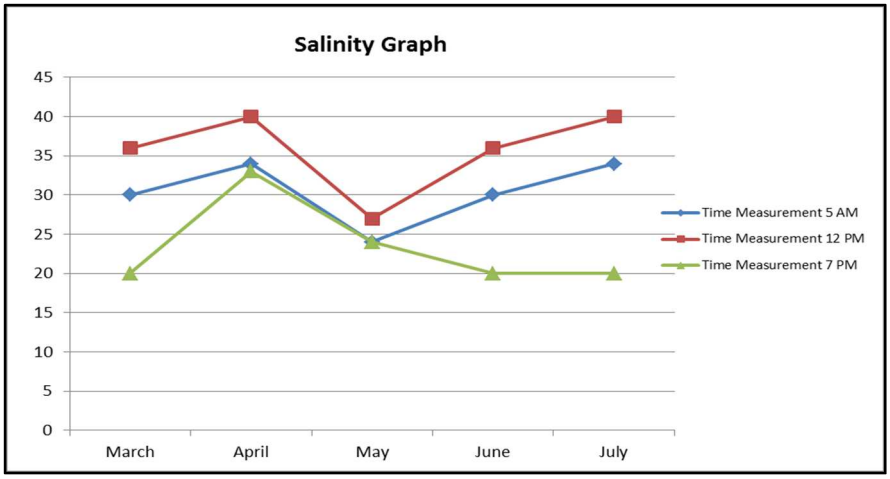

Fig. 8 Salinity Graph

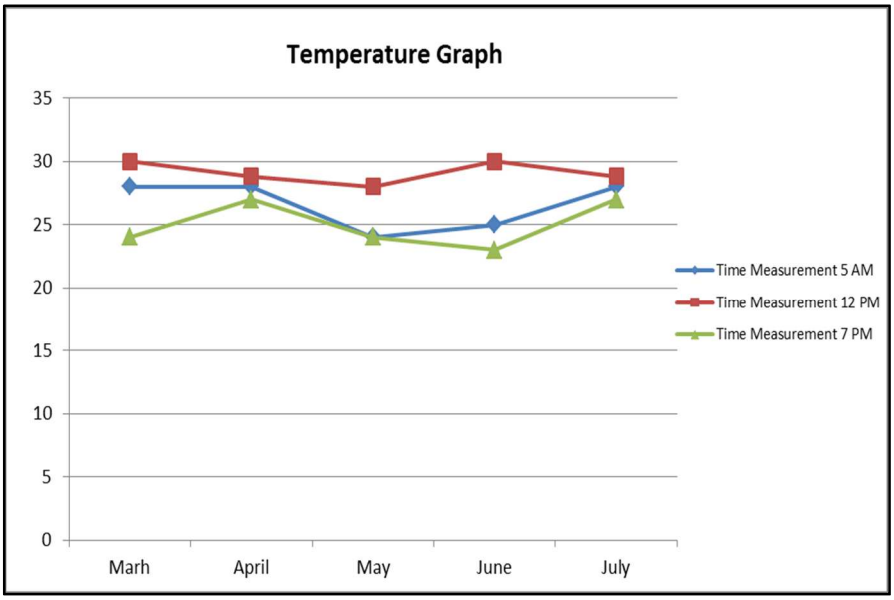

Fig. 9 Temperature Graph

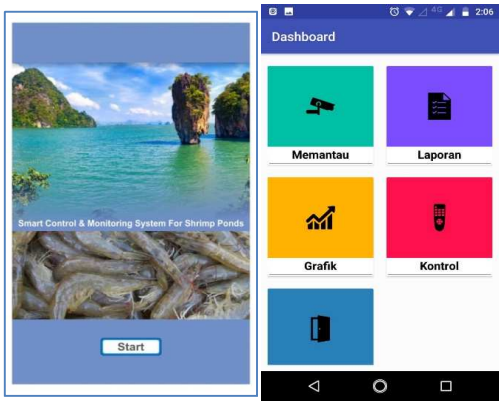

Fig. 10 Application Dashboard

The dashboard of the application is the main menu of the application, its designed with a user-friendly interface to make it easier to access every menu in the application. It has a Monitoring, Reporting, Graph, Control, and exit sub-menu.

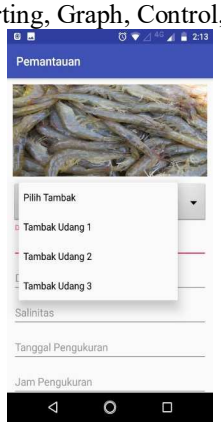

Fig. 11 Application sub-menu Monitoring

In this sub-menu, users can directly choose which shrimp pond to monitor; for example, if it has three shrimp ponds, it will have quick access to each pond. To monitor the water quality condition of each ponds.

Fig. 12 Application sub-menu Report

The report page displays a menu to display the contents of reports that have been created to see data that has been monitored, such as ph, temperature, and salinity. The user will easily get every detailed report of each pond, and its report can be downloaded into PDF format.

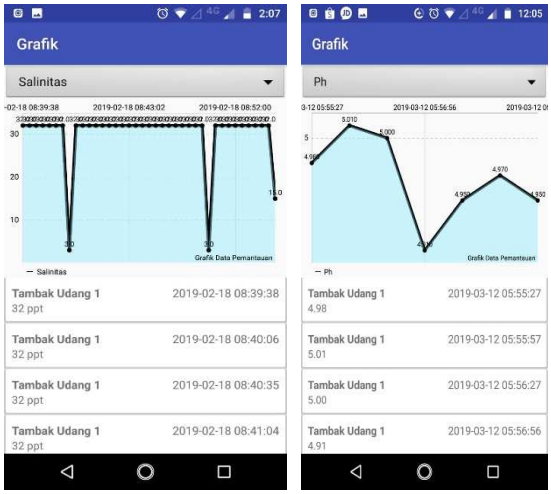

Fig. 13 Application sub-menu Salinity and pH Graph

Graph page is a view of the graph of pH, Temperature, and Salinity. Each of them has a display to display the value of pH, Temperature, and Salinity. Despite each sensor's value, the application also displays the history of data from temperature, pH, and salinity from time to time (depending on the configuration that we config). Each graph represents a parameter for every pond. With this graph for each parameter, the user will show the pond's quality and could perform preventive or optimization action to keep the pond quality in good condition. The Control menu allows users to connect to *Arduino* to each pond. Once it is connected to *Arduino*, all data will be delivered as per each function.

The notification will send whenever an event occurs in the ponds, as per setting. For example, the application will receive a notification when the temperature of the pond is below the threshold. It will directly send a text message to the application on user's Smartphone.

Fig. 14 Application sub-menu Control

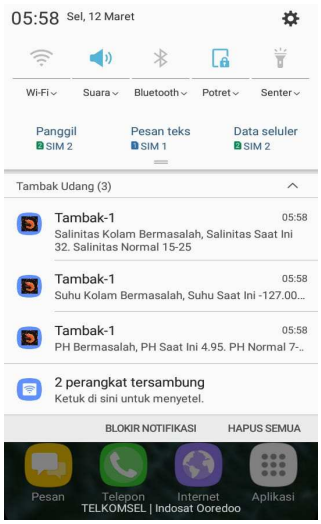

Fig. 15 Notification of the water quality Condition

IV. Conclusion

The Function of the water Spool is to anticipate oxygen deprivation in *vaname* shrimp as well as to help the water circulation when pond temperature is unstable, and the function of the water pump is to anticipate the high salt level in the pond so that the salinity is extremely high causing the process of molting on *vaname* shrimp disturbed. The error rate from each sensor is pH sensor that is 10,5% temperature sensor 0.05% and salinity14,9%, and the max value of water pH is nine occur after the rain, the salinity max value is 40ppt also occurring after rain and temperature are 30°C on March and June when dry season when measured at midnight.

As we can see from the experiment, the water temperature, pH, and salinity changed from time to time based on the season. The erratic season affects shrimp growth when the rain decreases the pH level in ponds. All the sensor's temperature, pH, and salinity work depending on the pond's conditions. The automation system helps the aquafarmer maintain their shrimp ponds easily and efficiently because they can be monitored and controlled using the equipment on the ponds using the android application. The android application also provides information on the water condition of the shrimp Ponds.

The changes in weather (temperature, humidity, and so on) impact the level of successful *vannamei* shrimp cultivation. Continuous rain conditions can adversely affect the pond pH water conditions because the water tends to be on high acidity, temperature changes occur in pond water, and when the temperatures cool down, the vanammei shrimp life force in salinity decreases the acidity and hardness of the ponds water. Thus, the physiological conditions of the shrimp will be disrupted when the source of disease for the shrimp is rising; hence, the shrimp lifeforce of will decrease.

Acknowledgment

This research was supported by Ristekdikti on Research Scheme PKPT between Politeknik Negeri Banyuwangi (Poliwangi) and Politeknik Elektronika Negeri Surabaya (PENS).

References

[1] Menteri Kelautan dan Perikanan, "Permen KP. No. 75 Tentang Pedoman Umum Pembesaran Udang Windu (Penaeus Monodon) Dan Udang Vaname (Litopenaeus Vannamei)," *Badan Karantina Ikan, Pengendali. Mutu dan Keamanan Has. Perikan.*, 2016.

[2] M. Junda, "Development of Intensive Shrimp Farming, Litopenaeus vannamei in Land-Based Ponds: Production and Management," *J. Phys. Conf. Ser.*, vol. 1028, no. 1, 2018.

[3] K. Preetham, "Aquaculture monitoring and control system : An IoT based approach," vol. 5, no. 2, pp. 4–7, 2019.

[4] N. Uddin *et al.*, "Development of an automatic fish feeder," *Glob. J. Res. Eng.*, vol. 10, no. 1, pp. 27–32, 2013.

[5] V. A. Wardhany, H. Yuliandoko, Subono, M. U. Harun Ar, and I. G. P. Astawa, "Fuzzy Logic Based Control System Temperature, pH and Water Salinity on Vanammei Shrimp Ponds," in *2018 International Electronics Symposium on Engineering Technology and Applications, IES-ETA 2018 - Proceedings*, 2019.

[6] E. N. S and P. D. E. N. A, "Water monitoring iot system for fish farming ponds," vol. 79, no. 2, pp. 77–79, 2018.

[7] H. A. Mohammed and I. Al-Mejibli, "Smart monitoring and controlling system to enhance fish production with minimum cost," *J. Theor. Appl. Inf. Technol.*, vol. 96, no. 10, pp. 2872–2884, 2018.

[8] R. H. Sudhan, M. G. Kumar, A. U. Prakash, S. A. R. Devi, and S. P., "Arduino Atmega-328 Microcontroller," *Ijireeice*, vol. 3, no. 4, pp. 27–29, 2015.

[9] O. Access, "Real time fish pond monitoring and automation using Arduino Real time fish pond monitoring and automation using Arduino," 2018.

[10] S. Chaudhary, V. Bhargave, S. Kulkarni, P. Puranik, and A. Shinde, "Home Automation System Using WeMos D1 Mini," pp. 4238–4241, 2018.

[11] K. G Sutar and P. T Patil, "Wireless Sensor Network System to Monitor The Fish Farm," *J. Eng. Res. Appl. www.ijera.com*, vol. 3, no. 5, pp. 194–197, 2013.

[12] D. Rana and S. Rani, "Fuzzy logic based control system for fresh water aquaculture: A MATLAB based simulation approach," *Serbian J. Electr. Eng.*, vol. 12, no. 2, pp. 171–182, 2015.

[13] Qurat-Ul-Ain, S. Iqbal, S. A. Khan, A. W. Malik, I. Ahmad, and N. Javaid, "IoT operating system based fuzzy inference system for home energy management system in smart buildings," *Sensors (Switzerland)*, vol. 18, no. 9, pp. 1–30, 2018.

[14] F. Cavallaro, "A Takagi-Sugeno fuzzy inference system for developing a sustainability index of biomass," *Sustain.*, vol. 7, no. 9, pp. 12359–12371, 2015.

[15] P. H. B. Shinde, A. Chaudhari, P. Chaure, M. Chandgude, and P. Waghmare, "Smart Home Automation System using Android Application," pp. 2408–2411, 2017.