Mixing and Controlling the PH of Citrate and Phosphate with Website

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***Abstract*— In this study built an instrument capable of mixing and controlling chemical pH of citrate solution and phosphate solution as buffer solution. The problem often experienced in mixing chemicals is a matter of safety and the accuracy of the concentration of the mixing of the substance. The function of this instrument is to mix and control the pH of the citrate and phosphate solution. It is hoped that in the presence of this instrument, the manufacture of citrate solutions and phosphate solutions can be carried out electronically which does not involve manual calculations to obtain the desired pH of the solution, and is relatively safe from direct contact with chemicals. This instrument is built using a pH sensor as the sensing pH value of the solution to be made. And as a controller used microcontroller. Results of pH control other than can be stored in the database, can also be transmitted to the internet (website) using a wifi interface device. Mixers and pH controls of citrate and phosphate have been realized and resulted in good pH control.**

***Keywords*— citrate, phosphate, pH, Website**

I. Introduction

Mixing of chemical substances for the purpose of obtaining a certain pH is indispensable both on a laboratory scale and in the pharmaceutical industry, pharmaceutical industry and others. Mixing of chemical substances, apart from requiring relatively complicated calculations to get a certain solution concentration or pH value, also often requires a lot of time, as well as the safety factor being exposed to chemical splashes or spills.

This paper provides a time control fluid mixing system in a tank with the application of a discrete fuzzy timing control model. These systems are designed for a variety of industrial applications. The control system simulation design has three inputs: volume, viscosity, and product selection, along with three external control adjustments for system calibration [1]. In this system, a temperature and volume based liquid mixing system is designed using three low-cost microcontrollers. The main function of this system is to mix different liquids with the required ratio and temperature [2]. In this study, a fiber-optic fluorosensor is presented that can be used to measure changes in blood pH continuously and accurately. Continuous intra-arterial blood pH monitoring is required in clinical practice [3].

Use of a paired coil pH sensor for remote high-resolution pH monitoring. This sensor uses a passive LC coil resonator with a resonant frequency that is monitored remotely, which measures the change in the impedance of the interrogator coil integrated into the sensor coil. Remote pH monitoring in various fields can be applied such as environmental monitoring, biomedical sensing, structural health monitoring. and industrial and chemical processing [4]. This tool is a system development aimed at monitoring conductivity and pH for 24 hours during the entire production cycle. In addition, it is possible to automatically adjust variations in dispensing acid / base solutions or nutrients [5]. Remote pH monitoring provides an integrated wireless passive sensor that uses temperature compensation. The sensor used is calibrated at a temperature range of 25 ° C - 55 ° C and a pH in the dynamic range of 1.5–12. Using temperature compensation, a measurement accuracy of less than 0.1 pH is achieved and a sensor response time of less than 1 second [6].

A cost-effective stand-alone automatic liquid mixer has been constructed using chaotic PWM control. These liquid mixers offer a potential alternative to liquid mixing in industrial automation [7]. In another paper that has been made in the style of automatic liquid mixing and bottle filling, this system proposes an automated industrial application of mixing and filling management. Its controls and monitoring are easily accessible and the operator will be alerted by the system if something goes wrong [8]. This tool controls various environmental conditions, the speed and duration of shaking the semi-solid liquid required for the microbiology/chemical research laboratory using a microcontroller. The microcontroller monitors and controls environmental conditions, namely humidity, temperature and provides a choice of speed and duration of orbital movement shaking [9].

The design of a ratiometric fluorescent chemical probe was carried out to monitor and image mitochondrial pH in living cells using a modified conco-red double emission semiconductor point polymer via a competitive fluorescence resonance energy transfer (FRET) mechanism [10]. A mixer designed with CAD/CAM tools has been created. This tool uses a microcontroller which functions to control the speed of mixing chemicals [11]. A device design that can mix three different liquids wirelessly using raspberry pi has been proposed. The mixing of the three liquids is carried out automatically using an ultrasonic sensor [12].

From this background, in this study a way out to answer this problem was considered by designing an instrument capable of mixing chemical substances as well as determining the pH of the solution and its control. The chemical substances to be made and pH controlled are citrate and phosphate buffer solutions. Both of these substances can be made and pH controlled simultaneously using a pH sensor

[13]–[17], flow sensor and controlled using a microcontroller. The results can not only be stored in a database, but can also be transmitted via the internet (website) [18]–[22].

The benefit that can be obtained from this instrument is that it can overcome the mixing time and control of the pH of the solution which is relatively long, no more expertise or chemical knowledge is needed to mix and get the desired pH.

II. METHODS

The system design that is carried out includes hardware and software design. In the hardware design section, a system that combines a pH sensor with a microcontroller controller is built [23]–[27]. The system is also equipped with an interface in the form of an ethernet shield that connects to the website. The block diagram of the hardware system design is shown in Figure 1.

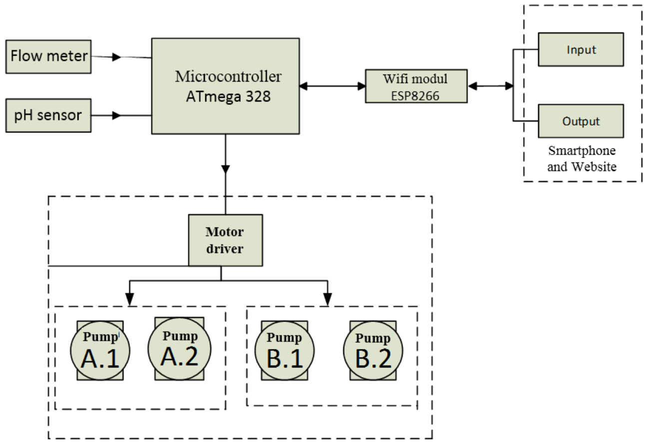

Fig. 1. Block diagram of the system design

A. Hardware Design

From the block diagram of the system design shown in Figure 1, there is a smartphone device that is used by the user to select the buffer solution or substance to be made or pH controlled. The parameters entered are the volume of the chemical liquid and the desired pH value. From the pH value entered by the user, this is what then activates the pH sensor to sense and take the pH value of the solution being mixed or controlled. The parameters obtained from the pH sensor are then carried out by the communication process to send data from the smartphone to the ESP8266 Wi-Fi module and will be directly forwarded to the microcontroller. In the microcontroller, the water volume and pH values are processed and matched to a pH parameter procedure. Then the microcontroller will activate the two pumps from one of the buffer solutions to be made. As long as the pump is active, the flow sensor continues to read and maintain the solution flow value until the solution values that have been removed from pumps 1.A and 1.B for Solution 1, and pumps 2.A and 2.B for Solution 2 are appropriate. When the digital value through the ADC contained in the microcontroller has been obtained, the value is sent v`ia the ESP8266 Wifi module wirelessly and will be received by the smartphone to be displayed and stored as an activity log. In addition, the microcontroller also forwards it to the website from the Android application so that data can be forwarded to the database to be displayed on the website as activity log data on the website.

Table 1 provides an explanation of the block diagram shown in Figure 1.

TABLE 1. EXPLANATION OF THE BLOCK DIAGRAM

No	Device	Function
1	ESP8266 wifi module	Serves to provide wireless data communication that will receive data from a smartphone, then the data is forwarded to the microcontroller.
2	Smartphone	Serves for bidirectional communication with the wifi module. The data sent is in the form of liquid volume, while the data received is the pH value.
3	Microcontroller	Serves to process input from the wifi module, pH sensor and flow sensor. In addition, the microcontroller also controls the motor driver.
4	Motor Driver	The motor driver used is the Arduino L298P which functions to drive and stop the pump motor.
5	Pump 1A and pump 1B	Serves to pump the solution from the two solution containers. This pump is activated by a signal coming from the motor driver. This pump is specially used for citric acid and sodium citrate solutions.
6	Pump 2A and pump 2B	Serves to pump the solution from the two solution containers. This pump is activated by a signal coming from the motor driver. This pump is specifically used for other buffer solutions.
7	Flow sensor	Flow sensor is a digital sensor which functions to read the liquid flow continuously as long as the pump is active.
8	pH sensor	This pH sensor is still an analog signal that is converted to digital by the ADC contained in the microcontroller.

The microcontroller used is the Arduino Uno Atmega 328P-PU. The microcontroller ports or pins used in this design can be seen in Table 1.

TABLE 2. MICROCONTROLLER PINS USED

No	Sensor and component	Pin of Arduino
1	pH Sensor	A0
2	Wifi module ESP8266	Rx 2 and Tx 3
3	Flow sensor	4, 5, 6, 7
4	Relay	A1, A2, A3, A4, 9, 8
5	Motor driver	Vin, 10, 11, 12, 13

Figure 2 is a microcontroller based system device connected to I / O (input / output). There is a wifi module ESP8266, this device is used to provide wireless data communication. This wifi module will receive data from the smartphone and then forward it to the Arduino Uno microcontroller on the Rx 2 and Tx 3 pins, then the data obtained from the sensor sent from the microcontroller is returned to the smartphone and website. The pH sensor is used as a pH sensor obtained in the solution container. This pH sensor is connected to Pin A0 of the Arduino Uno microcontroller [16]–[18] [28]–[30]. After the pH value has been obtained, the results will be processed on the Arduino Uno microcontroller and sent back to the smartphone and website. The flow sensor is used for monitoring the volume of water that comes out of the mixing container. This flow sensor is connected to Pin 4,5,6,7 of the Arduino Uno microcontroller (there are 4 flow sensors).

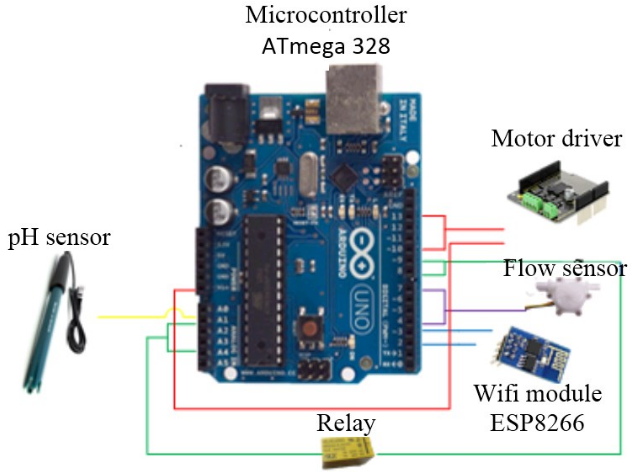

Fig. 2. Connection of microcontroller and I/O systems

B. Software Design

In this software design, two flow diagrams that play a role in controlling the system will be explained, namely the android application program flow chart, and the website interface flow chart. Figure 3 describes the interface on the Android side, namely:

a. Button (A): Input IP and Port used.
b. Button (B): Activation, to connect to wifi.
c. Button (C): Input volume and pH options for the solution to be made.
d. Button (D): If you have selected the solution to be made, the tool will work as entered in Button (C)
e. Button (E): The button on the datalogger corresponds to the label on the button.
- Add Data: used to ask whether the data will be saved or not
- Update: if there is the same data, the data will not overlap
- Delete: deleting data from the datalogger
- View All: to see all data that has been created and saved.

Each button in this application can run according to its function if the button is executed in the order above.

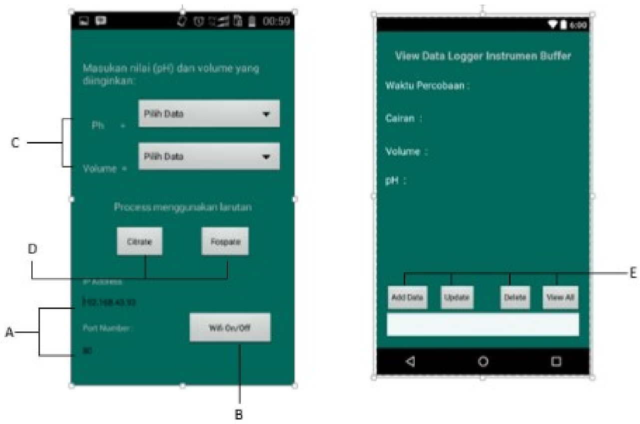

Fig. 3. Display of the android program interface

Figure 4 shows the flow chart of the android program. This flowchart contains an outline of an input from the user and an output from the microcontroller.

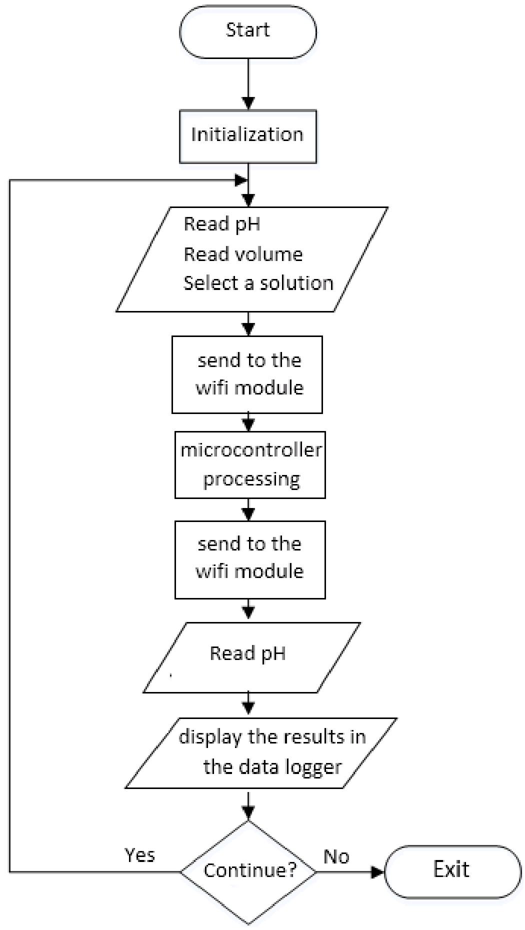

Fig. 4. Flow diagram of the android application program

Figure 4 shows the flow chart of the android program. This flowchart contains an outline of an input from the user and an output from the microcontroller.

III. Implementation

The testing process is carried out to find out whether the system created is able to function as expected. Tool testing is carried out on each sub module independently and after that the whole system is tested.

A. Testing of Flow Sensor

Figure 5 shows a sample taken from measurements. The output test on the flow sensor is done by measuring the volume of the substance (using liters). This test is carried out in an independent way which is monitored directly using the serial monitor on the Arduino program.

Figure 5 shows the volume output in liters obtained from the equation.

$$\text{volume} = (\text{pulse} / 63) / 60 \tag{1}$$

So if the smallest pulse data is taken, which is 873 (see line 1 in figure 5), then the volume output = (873/63) / 60 = 0.2309 liters is obtained. Meanwhile, if the largest pulse data is taken, namely 898 (see the last line in figure 5), then the volume output = (898/63) / 60 = 0.2375 liters is obtained. This means that there is a difference of 0.0066 liters = 6.6 milliliters from the two values.

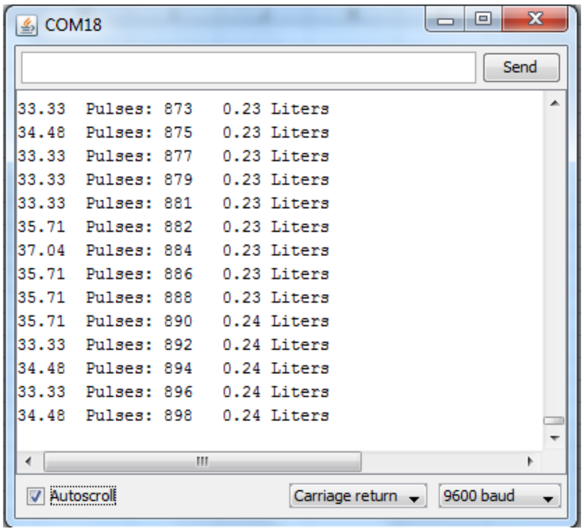

Fig. 5. Flow sensor measurements

B. *Testing of pH Sensor*

Testing on the pH sensor is carried out on both citrate and phosphate solutions by comparing it with standard pH digital measuring instruments and litmus paper. This test is also carried out repeatedly which aims to determine changes in the reading of the pH value with time.

TABLE 2. PH MEASUREMENT USING COMPARISON TOOLS

No	Type of solution	pH desired	Volume (ml)	pH on litmus paper	pH on standard equipment	pH on the design equipment
1	citrate	3	100	3	2.99	3.10
2	citrate	3	100	3	2.98	3.11
3	citrate	6	500	6	6.10	6.12
4	citrate	6	500	6	6.18	6.14
5	phosphate	4	200	4	4.60	4.45
6	phosphate	4	200	4	4.73	4.57
7	phosphate	8	400	11	11.09	11.12
8	phosphate	8	400	11	11.01	11.11

For the pH of the citrate solution, there was no significant difference when compared with the comparator (standard pH digital measuring instrument and litmus paper). Measurements at pH 7 and 8 for phosphate solutions did not produce the desired results on either a standard digital pH meter or using litmus paper. This is because the material used has a high level of corrosion value, where if it is enforced with this pH value, damage to the tool will occur because the material used cannot be polyester plastic, because it will melt easily. For this reason, the phosphate in this tool can only be made of pH 4.5 and 6.

C. *Website Testing*

Website testing is done in several ways, first the list menu, login, and whether the database is stored is appropriate or not. And also whether the user can log in and view the datalogger according to android or not.

The registration page is created on a separate form, by filling in the form directly on the registration page. Figure 6 shows the results of the page display for registration purposes.

Figure 6. Display of the menu for registration page

Figure 7 shows the results of the page display for login purposes.

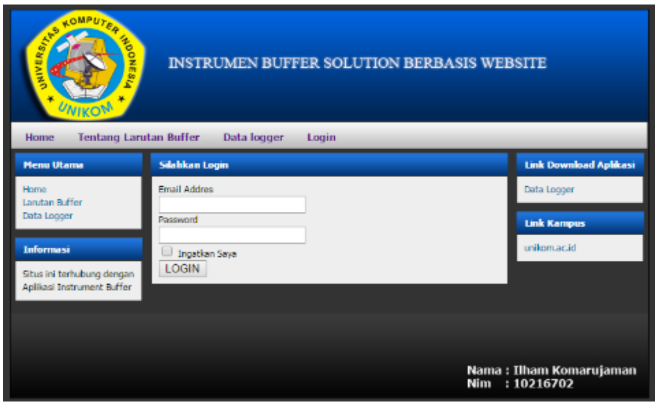

Figure 7. Display for the login page

Figure 8 shows the results of the page display for datalogger storage purposes.

Fig. 8. Display for datalogger storage.

IV. CONCLUSION

Testing on the Android application has functioned properly from 2 types of buffer solutions, namely citrate and phosphate. The pH value of the citrate buffer solution that was successfully prepared and controlled was pH 3 to 6. Meanwhile, the pH value of the phosphate buffer solution that was successfully prepared and controlled was pH 4 to 8. The datalogger for android applications and websites used in this system after testing, has succeeded in storing the volume value and pH value of the solution in each process.

REFERENCES

[1] M.S. Khan, K. Benkrid, "Design of liquids mixing control system using fuzzy time control discrete event model for Industrial Applications", in 2010 Journal of World Academy of Science, Engineering and Technology, Vo1.48, 2010, pp. 545-553.

[2] A.S.C.S. Sastry, K.N.H. Srinivas, V.S.R.G. Krishna, S. KiranKumar ”An automated microcontroller based liquid mixing system”, in 2010 International Journal on Computer Science and Engineering,Vol. 02, No. 08, 2010, pp. 2648-2651.

[3] W. Jin, L. Wu, Y. Song, J. Jiang, X. Zhu, D. Yang, C. Bai, “Continuous intra-arterial blood pH monitoring by a fiber-optic fluorosensor”, in 2011 IEEE transactions on biomedical engineering, vol. 58, No. 5, May 2011, pp. 1232-1238.

[4] S. Bhadra, G.E. Bridges, D.J. Thomson, M.S. Freund, “Electrode potential-based coupled c sensor for remote pH monitoring”, in 2011 IEEE Sensor Journal, vol. 11, No. 11, November 2011, pp. 2813-2819.

[5] D. S. Domingues , H. W. Takahashi, C. A.P. Camara, S. L. Nixdorf, “Automated system developed to control pH and concentration of nutrient solution evaluated in hydroponic lettuce production”, in 2012 Computers and Electronics in Agriculture, 2012, pp. 53-61.

[6] S. Bhadra, D.S.Y. Tan, D.J. Thomson, M.S. Freund, G.E. Bridges, “A wireless passive sensor for temperature compensated remote pH monitoring”, in 2013 IEEE Sensors Journal, vol. 13, No.6, June 2013, pp. 2428-2436.

[7] S. Honglad and W. San-Ur, “Automatic stand-alone liquid mixer with chaotic PWM control using diode-based Rossler system”, in 2014 Proceedings of the International Electrical Engineering Congress, October 2014.

[8] S. R. Kurkute, A. S. Kulkarni, M. V. Gare, S. S. Mundada, “Automatic liquid mixing and bottle filling-A Review”, in 2016 International journal of innovative research in electrical, electronics, instrumentation and control engineering, Vol. 4, Issue 1, January 2016, pp. 57-59.

[9] A. Mohini, “Microcontroller Based Orbital Motion Shaker”, in 2016 International Conference on Emerging Trends in Engineering, Science and Technology, 2016, pp. 1194-1202.

[10] J. Sun, P. Ling, F. Gao, “A Mitochondria-Targeted Ratiometric Biosensor for pH Monitoring and Imaging in Living Cells with Congo-Red-Functionalized DualEmission Semiconducting Polymer Dots”, in 2017 Anal. Chem. publication, October 2017, pp. 11703-11710.

[11] A. K. Patel, A. Jha, A. Patwardhan, J. Pawar, R. Henry, “Design and fabrication of low cost vortex mixer using additive manufacturing”, in 2018 International Journal of Research in Advent Technology, Vol.6, No.12, December 2018, pp 3513-3516.

[12] M. M. Abdulwahab, A. Babiker, T. Abdulrhman, M. Elnoor, “Design of wireless control mixing system of liquids using Raspberry Pi device”, in 2020 International Journal of Electrical Engineering and Applied Sciences, Vol. 3, No. 1, April 2020, pp. 27-31.

[13] A. F. Rachmani and F. Y. Zulkifli, “Design of IoT Monitoring System Based on LoRa Technology for Starfruit Plantation,” in TENCON 2018 - 2018 IEEE Region 10 Conference, 2018, vol. 2018-Octob, no. October, pp. 1241–1245.

[14] C. Patrascioiu and G. Stamatescu, “Monitoring pH with HART communication,” in 2017 9th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS), 2017, vol. 2, pp. 864–869.

[15] D. Saraswathi, P. Manibharathy, R. Gokulnath, E. Sureshkumar, and K. Karthikeyan, “Automation of Hydroponics Green House Farming using IOT,” in 2018 IEEE International Conference on System, Computation, Automation and Networking (ICSCA), 2018, no. 1997, pp. 1–4.

[16] N. Kumar Koditala and P. Shekar Pandey, “Water Quality Monitoring System Using IoT and Machine Learning,” in 2018 International Conference on Research in Intelligent and Computing in Engineering (RICE), 2018, pp. 1–5.

[17] A. Fatani, A. Kanawi, H. Alshami, A. Bensenouci, T. Brahimi, and M.-A. Bensenouci, “Dual pH level monitoring and control using IoT application,” in 2018 15th Learning and Technology Conference (L&T), 2018, pp. 167–170.

[18] K. Srinivasan, V. Harikrishnan, R. S. Vinoth Venkatesh, and S. Gowtham, “Smart Monitoring and Auto-Neutralization of pH of Alkaline Liquids in Process Industries,” 2018 2nd Int. Conf. Smart Sensors Appl. ICSSA 2018, pp. 99–104, 2018.

[19] S. L. Ntella, F. Stradolini, A. Tuoheti, D. Demarchi, A. A. Hatzopoulos, and S. Carrara, “Architecture and procedures for pH and temperature monitoring in medical applications,” Proc. IEEE Sensors, vol. 2017-December, pp. 1–3, 2017.

[20] Helmy, M. G. Mahaidayu, A. Nursyahid, T. A. Setyawan, and A. Hasan, “Nutrient film technique (NFT) hydroponic monitoring system based on wireless sensor network,” 2017 IEEE Int. Conf. Commun. Networks Satell. COMNETSAT 2017 - Proc., vol. 2018-January, pp. 81–84, 2017.

[21] B. Siregar, S. Efendi, H. Pranoto, R. Ginting, U. Andayani, and F. Fahmi, “Remote monitoring system for hydroponic planting media,” 2017 Int. Conf. ICT Smart Soc. ICISS 2017, vol. 2018-January, pp. 1–6, 2017.

[22] P. V. Vimal and K. S. Shivaprakasha, “IOT based greenhouse environment monitoring and controlling system using Arduino platform,” 2017 Int. Conf. Intell. Comput. Instrum. Control Technol. ICICICT 2017, vol. 2018-January, pp. 1514–1519, 2017.

[23] D. Manyvone, R. Takitoge, and K. Ishibashi, “Wireless and Low-Power Water Quality Monitoring Beat Sensors For Agri and Acqua-Culture IoT Applications,” in 2018 15th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 2018, pp. 122–125.

[24] V. Suryawanshi and M. Khandekar, “Design and Development of Wireless Sensor Network (WSN) for Water Quality Monitoring Using Zigbee,” in 2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS), 2018, no. Iciccs, pp. 862–865.

[25] R. J. Agpangan et al., “Development of a Compact-Sized Biodigester for Pig Manure and Organic Wastes with Raspberry Pi-Based Temperature, Pressure, and pH Level Monitoring,” 2018 IEEE Reg. 10 Symp. Tensymp 2018, pp. 169–173, 2018.

[26] M. Lavanaya and R. Parameswari, “Soil Nutrients Monitoring For Greenhouse Yield Enhancement Using Ph Value with Iot and Wireless Sensor Network,” in 2018 Second International Conference on Green Computing and Internet of Things (ICGCIoT), 2018, pp. 547–552.

[27] M. S. M. Pakpahan, E. D. Widianto, and R. Septiana, “Analysis on Batik Water Waste Monitoring System based on LoRa Communication,” in 2018 5th International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE), 2018, pp. 171–175.

[28] B. Lyu, M. Punjiya, Z. Matharu, and S. Sonkusale, “An improved pH mapping bandage with thread-based sensors for chronic wound monitoring,” Proc. - IEEE Int. Symp. Circuits Syst., vol. 2018-May, pp. 2018–2021, 2018.

[29] T. Photsathian, T. Suttikul, and W. Tangsrirat, “Design and improvement of wireless crayfish breeding system by controlling water temperature and monitoring pH via cloud system services,” in 2018 3rd International Conference on Control and Robotics Engineering (ICCRE), 2018, pp. 205–208.

[30] F. José Mardones, A. I. Arrau, and R. S. Pincheira, “Data register and variable monitoring system from water stream in forest and plantation basins,” 2017 Chil. Conf. Electr. Electron. Eng. Inf. Commun. Technol. CHILECON 2017 - Proc., vol. 2017-January, pp. 1–6, 2017.