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IOT-Based Intelligent Green Houses (IGH) using Lo-Ra Technology

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This paper presents the design of the Internet of Things (IoT) platform for real time monitoring and controlling systems of the Intelligent Green House (IGH) at Politeknik Port Dickson. The implementation of the existing IGH is operated separately between Green Gardens and Aquaponics. Therefore, with the emergence of IoT technologies in recent years, this research proposes a complete solution for data centralization to ensure data efficiency and sustainability. The new IGH system consists of integrated sensors with a Long-Range Radio (Lo-Ra) platform used to send the pH, humidity, turbidity and temperature value of Aquaponic and moisture value of soil garden to the IoT platform. The proposed complete monitoring system of IGH was designed using Laravel that is capable to visualize the real time data. This paper is focused on the pH value and web page monitoring and testing. From the results, it is observed that the IoT platform successfully achieves the goals to display the value of pH and web application.

Key words: *Aquaponic, Green House Monitoring System, Internet of Things, Lo-Ra.*

Introduction

A greenhouse (also known as a glasshouse) is a structure with walls and roof made chiefly of transparent material, such as glass, in which plants acquire regulated climatic conditions to grow. Greenhouses have very important role in agriculture in all around the world, including Malaysia. The greenhouse is the advanced facility available in which we can control the climate to increase plant growth and avoid the effect of season changes on the plants. Inside the greenhouse moisture, air flow, and light can be controlled, unlike the outdoor farming temperature. This control gives efficiency to the greenhouses' production (Akshay et al., 2012). One of the cultivations in greenhouses is hydroponics. Most of the hydroponic crops are unsuccessful, mainly due to the lack of nutritional aspects in this production system, which requires adequate preparation and management of the nutrient solution and the chemical content of the hydroponics (Anif et al., 2017; Ramkumar and G. Rajini, 2018). The primary advantage of greenhouse technology is that it is used to protect the plants from the adverse climatic conditions such as wind, cold, excessive radiation, extreme temperature, insects, and disease (Durmuú et al., 2016) (Khattab et al., 2016).

Aquaponics is the combination of aquaculture (raising fish) and hydroponics (the soil-less growing of plants) that grows fish and plants together in one integrated system. The aquaculture research community introduced the idea of Aquaponics in the mid-1970s (Shenan et al., 2017). This system has been in existence since ancient times. There is evidence that the Aquaponics system for growing crops is a sustainable, easy, and simple method of farming when compared to traditional methods of farming which involves a lot of hard work (Kilicdagi and Yilmaz, 2014). The Aquaponics system can be very helpful to the farmers residing in areas with a shortage of water. The problem that arises with the Aquaponics system is the amount of data needs analysis and manipulation to optimize the results (Love et al., 2015). The various environmental parameters such as pH, temperature, humidity, turbidity, eC and moisture need to be monitor and any change of this parameters could affect the aquaponics environment (Manju et al., 2017) (Nichols, 2017). This can be a quite a difficult task for a person to monitor daily.

With these problems, it is very necessary to design a real-time smart monitoring and control system. The real-time control of real-world devices has shown commercial value and ease the consumer. Real-time environmental information can be remotely gathered from the Aquaponics fields and transferred to where it can be processed to discover problems, store data, and/or take needed actions. The use of Wireless Sensor Networks (WSN) in agriculture increases the efficiency, productivity and profitability of many agricultural production systems (Pasha et al., 2018). The integration of WSNs with IoT can be applied to the analysis of data generated by sensors and IoT devices. The IoT is driven by an extension of the Internet through the incorporation of physical articles joined with a capacity to provide more quick-witted administrations to the earth as more information ends up noticeably accessible. Several application areas going from Green-IT and vital effectiveness to coordination's are now beginning to profit by Internet of Things ideas (Preetham et al., 2019). Therefore, this paper proposes a cloud-based architecture that is applicable to enable data monitoring, gathering, and actuation for sensors and IoT devices from hydroponic, fish ponds, and gardens at our Intelligent Green House (IGH) PoliPD. Emphasis is given more on viewing the pH value and testing the web application interface.

Related Works

There have been many works on monitoring and control system such as Wang et al (Rubiat et al., 2017) who proposed the Smart Monitoring and Control System Based on OpenWrt to monitor flow meters, pH, ultrasonic range finders, and digital temperature sensors, as well as principles of signal conditioning and closed loop control. The proposed system is an intelligently interactive application, where users can also use the mobile terminal to monitor and control the smart aquaponics. The hardware system consists of Arduino and WRTnod which is based on Wi-Fi AP-Soc, an open source development board hardware.

Muhammad Anif et al (Saaid et al., 2013) proposed the Internship Monitoring System Web Based to manage the internship process at Politeknik Negeri Semarang that can be accessed by five level of users such as administrators, head of program, faculty, students, and field supervisors. The system uses the Laravel framework that applies the Model-View-Controller (MVC) method.

Pasha et al (Love et al., 2015) proposed the control and monitoring Aquaponic system based on IoT, which enables the function to monitor water level, temperature, and pH level that can be accessed by various smartphones and browsers and can also control the lights and water pump through the web. A raspberry pi device is used as the gateway of sensor readings while Arduino Uno is used for monitoring purposes and Arduino Nano for controlling.

Shaout and Scott (Samal and PatiMulti, 2014) proposed the control and monitoring fish tank and growing bed in an aquaponic ecosystem using IoT fuzzy locic. The system will monitor water temperature, pH, air temperature, and luminance. The system will control a light, heater, and the alarm. The system uses the Arduino Uno R3 board to be the hardware interface for inputs/outputs.

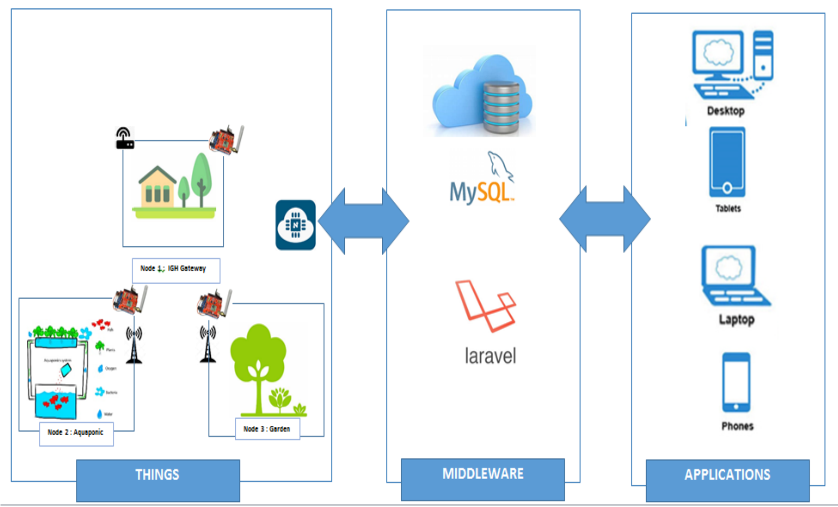
Methodology

A. IGH PoliPD System Design

A Lo-Ra device is used as the gateway of sensor readings and controlling. LoRa is the best option for IoT solution which requires a long range of data communication while keeping very little power usage (Saraswathi et al., 2018). All sensors are connected to the Arduino device and the communication between Arduino and Lo-Ra device is done by the Arduino program. DHT11 humidity and temperature sensor is used to measure the humidity and the temperature, DFROBOT 109 analogue pH meter is used to measure the water pH level while DFROBOT 038 turbidity sensor is used to measure the turbidity. Data can be acquired using a low-cost Arduino microcontroller. The Arduino software, however, does not contain a suite of tools for data fitting and analysis (Seok-Oh et al., 2017). The data are typically gathered first and then imported manually into an analysis program. PLX-DAQ is used to import data directly from the Arduino to Excel and allows real-time plotting and analysis instead of viewing it in web application.

The NodeMCU is used as a hub to 2 nodes from Garden and Aquaponic as a transmitter and 1 gateway from IGH as a receiver. Other sensors are connected to their respective positions and these sensors send the data to the NodeMCU which consists of an inbuilt Wi-Fi technology. MySQL is a database available on the internet in which values of the sensors are updated every second in real-time. A web application is developed using the Laravel framework. Within the software, the connectivity between the web application and MySQL will be made. Therefore, the user can monitor the parameters from anywhere.

Figure 1. IGH PoliPD System Design



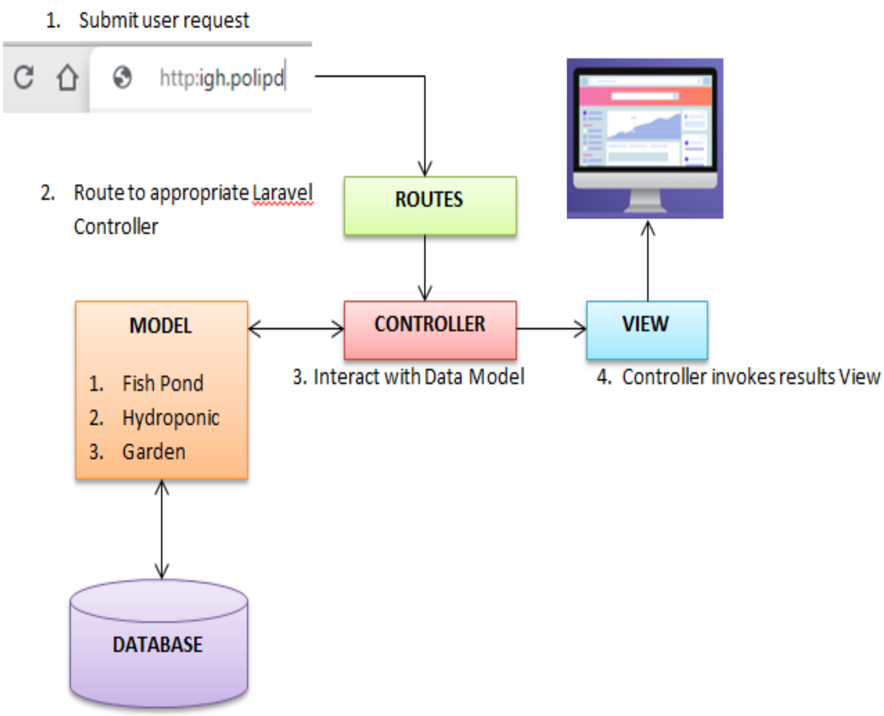
B. IGH PoliPD Web Application Framework

Developing a web application from scratch can be a tedious and complicated task. Over time, too many opportunities for bugs and too many revisions can make maintenance of a web application very frustrating for any developer (Shafeena, 2016). Because of this, a recently developed framework written in PHP, Laravel, has quickly won the hearts of developers around the world for its clean code and ease of usage.

The Laravel application follows the traditional Model-View-Controller (MVC) design pattern, where controllers are used to handle user requests and retrieve data while models interact with database and retrieve objects' information and view to render pages (Shaout and Scott, 2017). Additionally, routes are used to map URLs to designated controller actions.

The IGH PoliPD web application framework as in Fig. 1 shows that a request is made when a user enters a URL associated with the application. A route associated with that URL maps the URL to a controller action. That controller action leverages the necessary model(s) to retrieve information from the database, and then passes that data off to a view and to be display to the user.

Figure 2. IGH PoliPD Web Application Framework



Result And Discussion

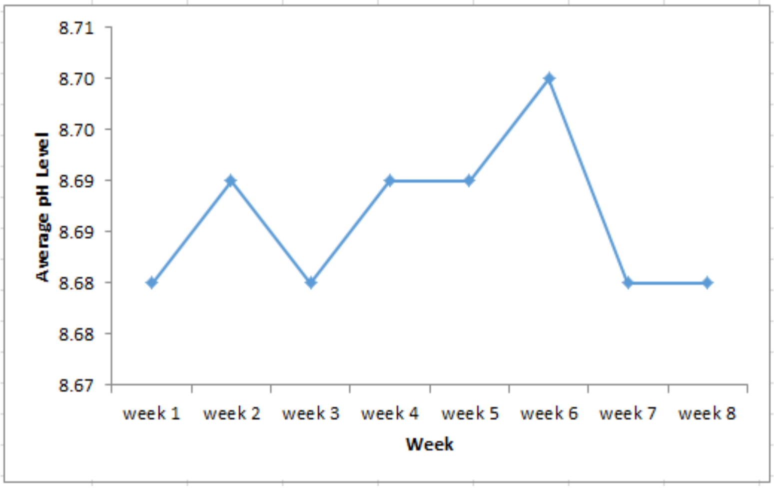
A. Sensor Testing

There are 2 aspects tested in the research: pH sensor testing and web page testing. pH is a measure of the acidity (or alkaline) of a solution. The range goes from 0-14, with 7 being neutral. pH of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base (Surguy, 2014). pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic (Zourmand et al., 2019). After the system is successfully implemented and running, the pH sensor is tested to get the pH water level by taking samples of comparison results for 8 weeks. The Arduino coding will work and thread the real-time data from the sensor in specified delayed time. Lastly, the web page will be tested by accessing it from another device that is in the same network. It will show all the data value that was sensed. Table 1 shows the average results of pH values for 8 weeks and Fig. 3 shows the pH average value in 8 weeks.

Table 1: Average results of pH values for 8 weeks

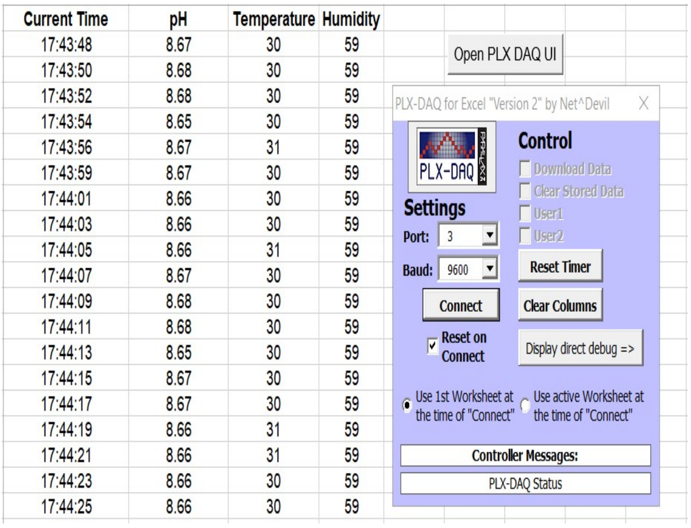
Week(s)	week 1	week 2	week 3	week 4	week 5	week 6	week 7	week 8
Average	8.68	8.69	8.68	8.69	8.69	8.70	8.68	8.68

Figure 3. pH average value



From monitoring the process within 8 weeks and approximately taken at the same time, it can be said that the water temperature recorded between 30-31 Celsius and the humidity of water recorded approximately 59, while the pH value is relatively between 8.5 to 8.8. This can be referred to Fig. 4 where the pH value data result taken from PLX-DAQ.

Figure 4. PLX-DAQ data taken from Arduino



Current Time	pH	Temperature	Humidity
17:43:48	8.67	30	59
17:43:50	8.68	30	59
17:43:52	8.68	30	59
17:43:54	8.65	30	59
17:43:56	8.67	31	59
17:43:59	8.67	30	59
17:44:01	8.66	30	59
17:44:03	8.66	30	59
17:44:05	8.66	31	59
17:44:07	8.67	30	59
17:44:09	8.68	30	59
17:44:11	8.68	30	59
17:44:13	8.65	30	59
17:44:15	8.67	30	59
17:44:17	8.67	30	59
17:44:19	8.66	31	59
17:44:21	8.66	31	59
17:44:23	8.66	30	59
17:44:25	8.66	30	59

B. Web Page Testing

The data from each sensor node will be displayed in a web page. The web page is designed to be able to look after limited data. Fig. 5 shows the main page of IGH PoliPD. The web page consists of 4 menus which are Greenhouse, Garden, Hydroponic and Fishpond. Fig. 6 shows the data for pH sensor display in the Fishpond menus. The web page interface is compatible with many browsers from many devices as shown in Table 2.

Figure 5. IGH PoliPD Web Page Interface

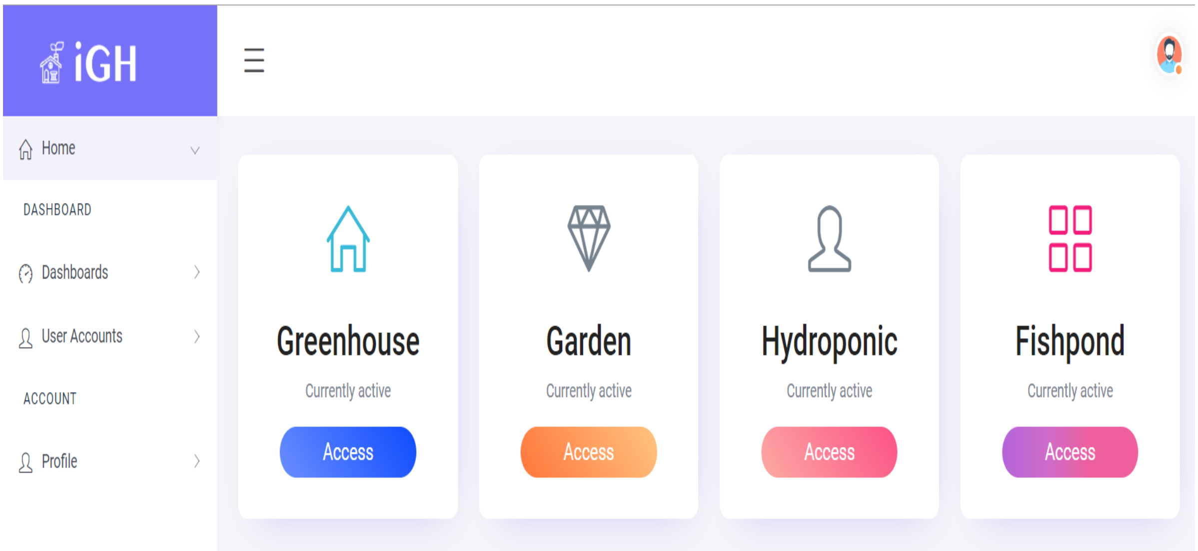


Figure 6. Data for pH Value, Turbidity and Temperature View Interface

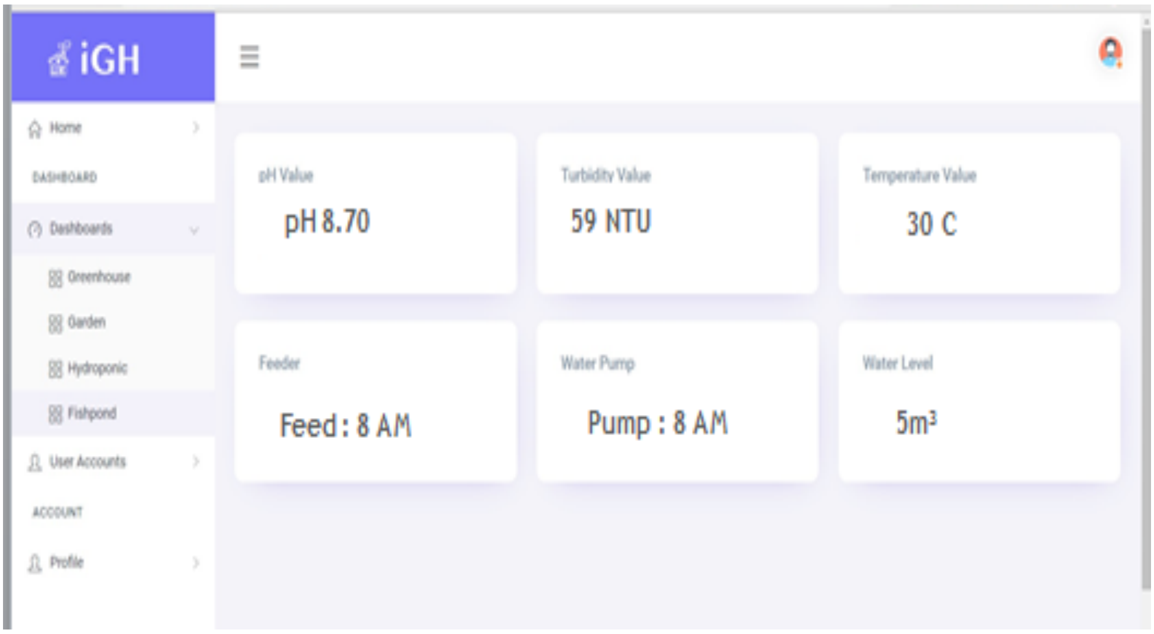


Table 2: Device(s) Compatible Table

Device(s)	Browser	Controlling	Monitoring
Huawei Nova 2Lite	Default Browser	Compatible	Compatible
	Opera Mini	Compatible	Compatible
iPhone 7	Safari	Compatible	Compatible
Acer Aspire 5	Chrome	Compatible	Compatible

Conclusion

The result output is varied between 8.5 to 8.8 for pH sensor value which was tested in the IGH PoliPD pond. The developed system allows displaying multiple Aquaponic parameters in specified delayed time. The parameters to be monitored includes the water temperature, pH level, and humidity. The information table showed in web page that can be accessed from various web browsers in various types of devices. The system was designed very simply to monitor and control. However, it can be developed to monitor more parameters and control more devices.

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REFERENCES

Akshay, C., Karnwal, N., Abhfeeth, K. A., Khandelwal, R., Govindraju, T., Ezhilarasi, D. and Sujan, Y. (2012). *Wireless sensing and control for precision green house management.* Sixth International Conference on Sensing Technology (ICST).

Anif, M., Dentha, A. and Sindung, H. W. S. (2017). *Designing Internship Monitoring System Web Based with Laravel Framework.* IEEE International Conference on Communication, Networks and Satellite (Comnetsat).

Durmuú, H., Güneú, E.O. & KÕrcÕ, M. (2016). *Data Acquisition from Greenhouses by Using Autonomous Mobile Robot.* Fifth International Conference on Agro-Geoinformatics (Agro-Geoinformatics).

Khattab, A., Abdelgawad, A. and Yelmarthi, K. (2016). *Design and Implementation of a Cloud-based IoT Scheme for Precision Agriculture.* 28th International Conference on Microelectronics (ICM).

Kilicdagi, A. and Yilmaz, H. I. (2014). *Laravel Design Patterns and Best Practices.* Packt Publishing.

Love, D. C., Fry, J. P., Ximin Li, Hill, E. S., Genello, L., Semmens, K. and Thompson, R. E. (2015). *Commercial Aquaponics Production And Profitability: Findings From An International Survey*. Journal Homepage: www.Elsevier.Com/Locate/Aqua-Online.

Manju, M., Karthik, V., Hariharan, S. and Sreekar, B. (2017). *Real Time Monitoring of the Environmental Parameters of an Aquaponic System Based on Internet of Things.* Third International Conference on Science Technology Engineering & Management (ICONSTEM).

Nichols, D. (2017). *Arduino-Based Data Acquisition into Excel, LabVIEW, and MATLAB.* The Physics Teacher.

Pasha, A.K., Mulyana, E., Hidayat, C., Ramdhani, M. A., Kurahman, O. T. and Adhipradana, M. (2018). *System design of controlling and monitoring on aquaponic based on internet of things*. IEEE.

Preetham, K., Mallikarjun, B.C., Umesha, K., Mahesh, F. M. and Neethan, S. (2019). *Aquaculture monitoring and control system: An IoT based approach*. International Journal of Advance Research, Ideas and Innovations in Technology.

Rubiat, I., Shaikh, M. F., Md. Ruhul, A., Farha, M. J., Mohammod, J. I., Md.Jahangir, A., Mohammad, N. H. and Mohammad, A. (2017). *Assessment of pH and Total Dissolved*

Substances (TDS) in the Commercially Available Bottled Drinking Water. IOSR Journal of Nursing and Health Science (IOSR-JNHS).

Ramkumar, A. and G. Rajini, 2018. Innovative human resource practices and selected H.R. Outcomes in software firms. International Journal of Innovation, Creativity and Change, 4(2): 134-157.

Saaid, M.F., Fadhil, N. S. M., Megat Ali, M. S. A. and Noor, M. Z. H. (2013). *Automated Indoor Aquaponic Cultivation Technique*. IEEE 3rd International Conference on System Engineering and Technology.

Samal, N. and PatiMulti, U. (2014). *Channel Data Acquisition and Data Logging for Green House Application*. IEEE Students' Conference on Electrical, Electronics and Computer Science.

Saraswathi, D., Manibharathy, P., Gokulnath, R., Sureshkumar, E. and Karthikeyan, K. (2018). *Automation of Hydroponics Green House Farming using IOT*. IEEE International Conference on System, Computation, Automation and Networking (ICSCA).

Seok-Oh, Y., Han, W.C., Ji-Hoon, S., Jeong-ho, P., Bong, G. C., Tae, J.L., Soon, J.K., Jong-Kwon, L., Chang-Ho, S., Hyung-Joun, Y. and Choul-Young, K. (2017). *Flexible Ph Sensor And System Fabricated Using PET Film*. IEEE SENSORS.

Shafeena, T. (2016). *Smart Aquaponics System: Challenges and Opportunities*. European Journal of Advances in Engineering and Technology, 3(2): 52-55.

Shaout, A. and Scott, S. G. (2017). *IoT Fuzzy Logic Aquaponics Monitoring and Control Hardware Real-Time System*. The International Arab Conference on Information Technology Yassmine Hammamet, Tunisia.

Shenan, Z. F., Marhoon, A. F. and Jasim, A. A. (2017). *IoT Based Intelligent Greenhouse Monitoring and Control System*. Basrah Journal for Engineering Sciences.

Surguy, M. (2014). *Laravel : My First Framework*. Leanpub Book.

Zourmand, A., Chan, W. H., Lai, K. H. and Mohammad, A.R. (2019). *Internet of Things (IoT) using LoRa Technology*. IEEE International Conference on Automatic Control and Intelligent Systems (I2CACIS).