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Portable Water Quality Monitoring System for Aquaponics using We MOS

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Abstract**:** ***Technology today had advanced rapidly for the betterment of our life. However, agriculture seems to be left behind in the rapid progress. With the growing population nationwide, more food is required especially in the agriculture sector. Aquaponics is an efficient approach for food production which combines plant and fish farming together. In aquaponics, water quality especially the water's pH level is crucial to be monitored regularly to ensure the fishes are in good health. However, measuring the pH level routine is no longer efficient today since the availability of technology. This study proposed a portable water quality monitoring system which currently only measures the water's pH level since it is the most important parameter in water quality. Mainly, the system uses WeMos board and Message Queuing Telemetry Transport (MQTT) protocol for data processing and sending it to a Raspberry Pi (base station) for storage and visualisation. The device has been successfully tested at the Malaysian Institute of Sustainable Agriculture (MISA). website. The device was proven waterproof and floatable. It also can run for about 89 hours on battery only without solar panel. However, there is always area for improvement which includes adding more sensors to optimise usage of the device and also a*** **Liquid-Crystal Display (LCD) screen for user convenience. Nonetheless, this is a step towards modernising the agriculture sector.**

Keywords**:** ***Aquaponics, monitoring system, water quality, WeMos.***

I. INTRODUCTION

Nowadays, technology has advances which improve human lives in multiple sectors such as wide application of Internet of Things (IoT) which has become a trend surrounding us every day [1]. The way human lives and works today will never be the same as the old days [2]. the world population has grown including in Malaysia. More people require more food source which mainly comes from plants [3].

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Therefore, technology is used in making agriculture more efficient without endangering the environment. Aquaponics is one approach which integrates plant and fish farming in a single system that relies on each other [4]. Aquaponics is an efficient way in food production involving plants and fishes simultaneously without endangering the environment [5]. Since aquaponics involves a water tank for fishes, water quality is an important factor to be kept monitored at all time to ensure the fishes are in good health. High acidity water harms the fish within the water and may even cause their death. Measuring water pH level on a daily basis using manpower has become inefficient today since the availability of technology to handle routine tasks. Furthermore, human resource can be reallocated to more challenging tasks which cannot be done by a computer. Other than that, a farm with several aquaponics systems might be quite costly to provide each with a water quality monitoring device. Thus, a portable water quality monitoring system was proposed in this study which can be used in aquaponics and other water-based farming. Design of the system is a combination of several previous works integrated together. A work by [6] proposed a smart water quality monitoring system using an Arduino and Wi-Fi module to a personal computer (base station) design which includes using cloud service and Android application. The design is simple in term of hardware and suitable for the study's application. However, in term of software, the design is quite complicated. A work by [7] shows a great advantage in case of network latency and supports diverse message payload sizes when using Message Queuing Telemetry Transport (MQTT) protocol for sending data in IoT-based water quality monitoring system. Thus, the messaging protocol is suitable to be implemented in this study. Another work by [8] uses an Arduino and Global System for Mobile Communication (GSM) module integrated with a Supervisory Control and Data Acquisition (SCADA) system for detecting water contamination using IoT. The system is sophisticated for crucial water quality monitoring but rather too complex for the application of this study since it involves too many software developments. Works by [9], [10], and [11] uses WeMos board for various IoT application such as smart garbage monitoring and collection system, IoT based agriculture monitoring system, and IoT based weather information prototype. The design is simple since the WeMos board comes with a microcontroller integrated with a Wi-Fi module built-in together. Based on the previous works, this study adopted the use of WeMos board along with MQTT messaging protocol with a little modification in term of software adaptation to suit with the study's application.

II. METHODOLOGY

A. Hardware Design

The hardware consists of electronic components and casing design. The heart of the electronic components is WeMos, an Arduino UNO compatible Wi-Fi board based on ESP8266EX microchip. The WeMos is powered from a 12V 1.2Ah lead-acid battery which is charged by a solar panel via a solar power manager module. An analogue pH sensor is connected to the WeMos via its single analogue input pin. Fig. 1 shows the electronic components design altogether.

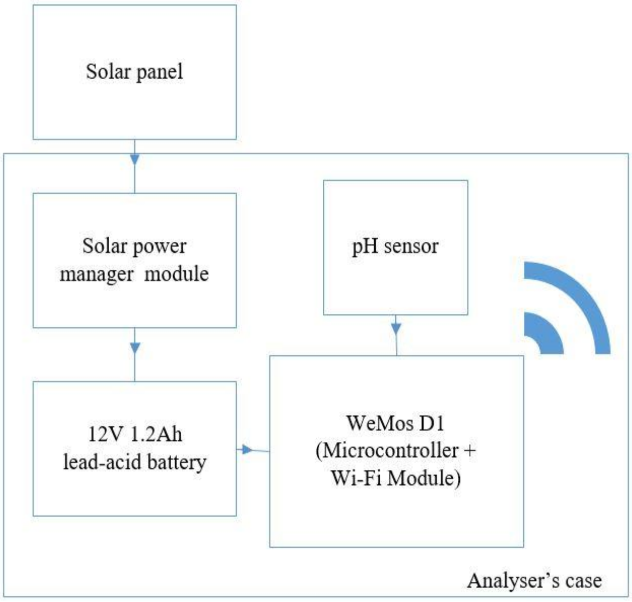

Fig. 1. Block diagram of the electronic components design.

The casing of the device is divided into three parts; buoyant, electronic component compartment, and sensor compartment as shown in Fig. 2. The buoyant was designed into doughnut-shaped to allow a small compartment for sensor to be placed at the centre of the buoyant and a larger compartment for electronic components on top of it both. The electronic component compartment is placed on top of the buoyant to ensure it situated within safe distance from water level. While the sensor compartment is placed in the middle of the doughnut-shaped buoyant to ensure the compartment is partially filled with water for taking measurement. The casing design focuses on waterproofness which is essential to protect the electronic components within. Thus, a plastic casing with plastic screws and rubber water seal at its cover was chosen. Other than that, the design also focuses on buoyancy which is critical for maintaining the device floating on freshwater at a suitable level to avoid water entering the electronic component compartment of the device. Therefore, the buoyant was made large in size using polyvinyl chloride (PVC) to support the weight. A steel handle is placed on opposite sides of the casing which can be attached to a chain for hooking the device at measurement location to prevent it from moving elsewhere.

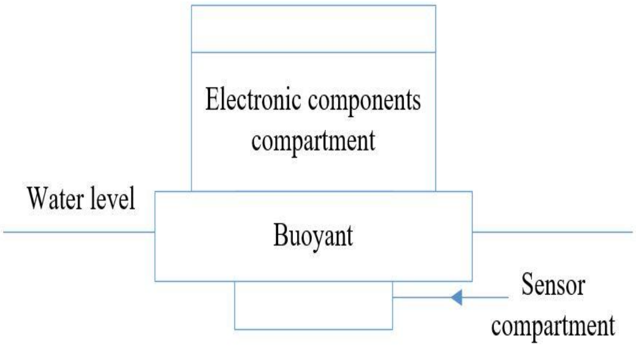

Fig. 2. Casing design of the device.

B. Software Design

Since this study uses an Arduino compatible board, WeMos, Arduino Integrated Development Environment (IDE) was used for programming the board. Analogue-to-Digital Converter (ADC) value reading is extracted from the pH sensor, converts it into pH value, and then sent to a base station which in this study is a Raspberry Pi via Wi-Fi using Message Queuing Telemetry Transport (MQTT) protocol. For connectivity between the WeMos and the Raspberry Pi, a portable Wi-Fi modem is used. At the base station side, a Python script was made to subscribe the MQTT topic for receiving the measurements from the device and send it to a local database. InfluxDB database is used in this study to store the measurements locally in the Raspberry Pi for visualisation using Grafana. InfluxDB is a time-series database (TSDB) suitable for real-time data collection and Grafana is a web server for visualising data from database. The highest data update rate for Grafana is 5 seconds which is acceptable for the study's application. Both InfluxDB and Grafana was installed on a local Docker platform which uses the concept of containerisation. In addition, Portainer was also installed on the Docker to give it a User Interface (UI) for user convenience in managing it. Fig. 3 shows operation flow of the system on the device and base station side respectively.

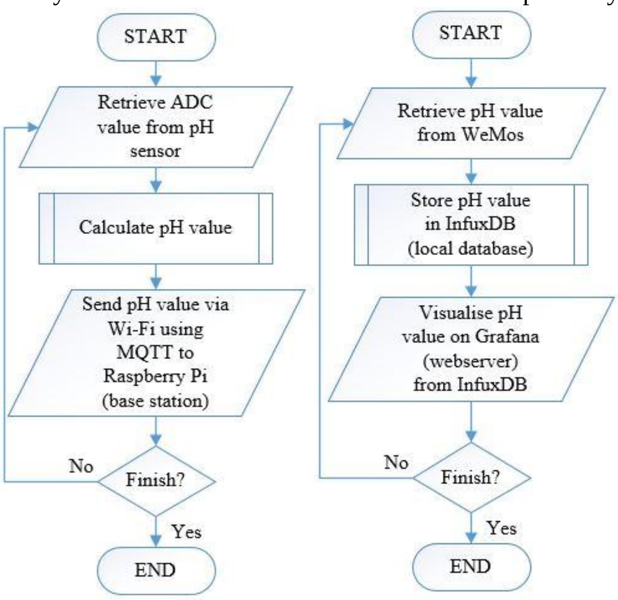

Fig. 3. Flowchart of the system.

C. Experimentation

Several tests were done at the Malaysian Institute of Sustainable Agriculture (MISA), a foundation focuses on organic and urban farming. A buoyancy test was done on the device by placing it in an aquaponics freshwater tank as shown in Fig. 4 with one-third of a sand-lime brick weighing a little less than 2 kg was placed in the electronic component compartment to more or less represent the weight of the electronic components inside. In addition, a plain white A4 paper was placed under the brick to observe for any water entering the electronic component compartment from the sensor compartment below via a sensor hole connecting the two compartments. In case of water present in the electronic component compartment, it will leave a wet mark on the paper. The device was left for a week in the tank. Other than that, the device was tested for taking measurements in an aquaponics water tank and displays it on the webserver. Furthermore, the device was also tested running on battery only which was fully charged to observe how long can the device run on the battery alone without a solar panel. When the device runs out of battery, it will no longer send measurement to the base station which can be observed from the webserver. The device was left for another week in the water tank for the experiment.

Fig. 4. Experimentation on the device at MISA's aquaponics.

III. RESULTS

The prototype was successfully produced according to the design. After a week, the paper does not show any sign of wetness which indicates no water had entered the electronic component compartment. Thus, the device is able to stay afloat on freshwater steadily without facing water leakage in the electronic compartment either from rain on its top cover nor from water in the sensor compartment. Electronic components are safe from water present in the compartment. In the next experiment, the device successfully measured and displayed measurement of pH level in the water tank on the webserver for user view as shown in Fig. 5. In the last experiment, data from the webserver shows that the device is able to run on a 12V 1.2Ah lead-acid battery for about 89 hours without charging using a solar panel. Thus, the battery used is sufficient to keep the device running continuously with aid of a solar panel for charging it in sunny days. Based on the results, the system is able function as required in the design without having any issue.

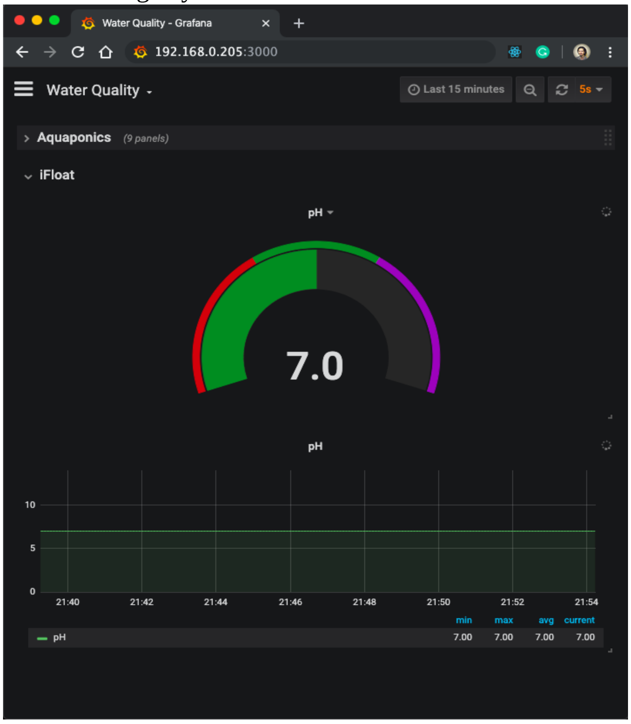

Fig. 5. Grafana dashboard (webserver) of the system.

IV. CONCLUSION

A prototype of a portable floating water quality measuring device which measures water pH level was made. The system was designed to be self-powered and self-charging using a small lead-acid battery and solar panel. The system uses MQTT messaging protocol for sending data to a base station where the data are stored and visualised on a locally hosted webserver. The result proves that the device is waterproof and able to float on freshwater. In addition, the device has a sufficient power supply in case of bad weather which reduces efficiency of its solar panel. The device was successfully integrated with a base station which uses Raspberry Pi and the data sent are visualised on the webserver. Thus, it shows that the device can easily be integrated into any base station which has Wi-Fi connectivity and a computer that supports MQTT. Moreover, it reduces MISA's staff routine in measuring water quality of the aquaponics. The device can be used for water quality measurement of several aquaponics systems since it is portable. Not only that, the device can also be used in other water-based farming in MISA. However, there is always room for improvement. The WeMos board used in this study only have one analogue input pin which limits the number of analogue sensors that can be used since most sensors produce analogue output reading. Alternative board or additional circuit can be used to support more sensors for optimising usage of the device. Other than that, a liquid-crystal display (LCD) screen which shows current sensor measurement and battery level indicator can be added for user convenience. This is a step towards modernising the agriculture sector with technology resource available today to increase efficiency and reduce human reliability.

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Muhamad Farhan Mohd Pu'ad graduated with a bachelor's degree in Electronics-Computer and Information Engineering and a master's degree by research mode in Electronics Engineering from International Islamic University Malaysia (IIUM). He was appointed as a research assistant at the Department of Electrical and Computer Engineering, Kulliyyah of Engineering, IIUM in 2019. He then proceeds his career as a Research and Development Engineer in a smart home development company. His area of interest is in the application of the Internet of Things (IoT) and image processing based Artificial Intelligent (AI).

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