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Aquaponic Monitoring System using Internet of Things

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Abstract: Aquaponics is a progressive and eco-friendly agricultural technique that merges aquaculture, which involves fish farming, with hydroponics, a method of cultivating plants without soil. The efficiency and productivity of aquaponic systems rely heavily on maintaining optimal environmental conditions for both the fish and plants. To achieve this, continuous monitoring and control of various parameters such as water level, temperature of water and pH level are crucial. The objective of this work is to establish an aquaponic monitoring system designed to monitor and track the physical conditions of crops. This system will employ a range of sensors to actively detect the current physical conditions and then transmit this data to a NodeMCU ESP32 microcontroller. Then, the data such as pH, temperature, water level, and water pump will be processed by NodeMCU ESP32 and uploaded to the Blynk IoT Cloud. The pH sensor determines the acidity or alkalinity of the water in the fish tank. The ultrasonic sensor is used to measure the level of water. The DS18B20 waterproof temperature sensor is used to monitor the water temperature. The aquaponics monitoring system includes an alarm notification function to inform users about critical conditions from desired parameters promptly. When a parameter exceeds or falls below predefined thresholds, the system triggers an alarm notification in the Blynk application on the phone to designated users. In this work, the pH value is 6.97. The water temperature is about 29-30 ºC. Then, the water level is 12 litres. The enhancements introduced in aquaponic farming practices are anticipated to lead to a substantial increase in crop productivity and quality.

Keywords: Aquarobics, Monitoring System, IoT, Blynk, Arduino

1. Introduction

In recent years, aquarobics has gained popularity as an indoor growing system [1]. Aquarobics is the union of hydroponics and aquaculture in a single integrated system [2][3]. Hydroponics is the practice of raising plants in water without soil. It combines biomass production from crop plants with wastewater treatment in recirculating aquaculture systems (RAS). Although the aquaponics system

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yields much more crops with less space needed, it requires much more attention towards the water parameter for maintaining healthy aquaponics for optimum yield [4]. A monitoring system can be used to help maintain an aquaponics system for the condition indicated.

The aquaponics monitoring system's primary tasks involve monitoring the water temperature, pH levels, and water level within the aquaponics system. It also incorporates an emergency alert system designed to promptly inform the user in case the water parameters deviate from safe levels. Furthermore, the system is configured to log and store data regarding these water parameters on an online platform, ensuring continuous user access. This recorded data serves as a valuable resource, enabling users to gain a deeper insight into the fluctuations occurring in the system's parameters over time.

2. Materials and Methods

2.1 Materials

Figure 1 shows the proposed system design consisting of a hardware and software implementation part. As for the hardware part, it consists of components such as ESP32, pH sensor, Polypropylene float switch sensor, Ultrasonic sensor, and temperature sensor (DS18B20). Meanwhile, for the software part, it used an Arduino IDE and IoT platform also known as a cloud where the selected cloud is Blynk.

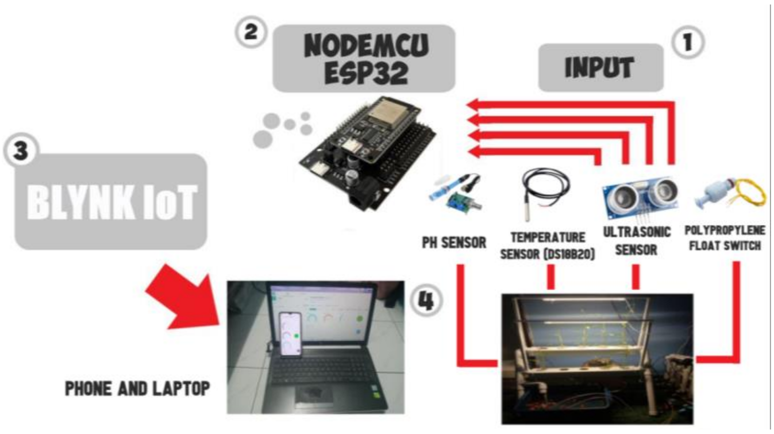

Figure 1: Mechanism of aquaponic monitoring system

The pH sensor stands out as a crucial tool in the realm of pH measurement, finding extensive application in the monitoring of water quality. It possesses the capability to discern the presence of alkalinity or acidity in various liquid solutions. In contrast, ultrasonic sensors rely on high-frequency ultrasonic waves to gauge the levels of both liquids and solids within a medium. Typically, these sensors or transmitters are affixed to a top tank and directed downward for their measurements. Meanwhile, the DS18B20 waterproof temperature sensor specializes in measuring temperature within liquids. Lastly, the polypropylene float switch falls under the category of level sensors, primarily utilized to ascertain the liquid levels within tanks. Its common applications encompass tasks such as controlling pumps, indicating water levels in tanks, triggering alarms, and integrating with other devices for control purposes.

The ESP32 is an economical and energy-efficient microcontroller equipped with integrated Bluetooth and Wi-Fi capabilities. It serves as a successor to the ESP8266, which was a low-cost Wi-Fi chip known for its severe limitations in functionality. The ESP32 microcontroller functions as the central processing unit (CPU) responsible for overseeing the data collected from sensors through its analog input pin. Blynk will be used as a web platform to store all relevant data. The user's commodity mobile phone or any electronic device will have free access to information. Any electronic device with a network connection, including a common mobile phone, can access the information in the Blynk database or add information. All of the functions are embedded in the mobile application. The data that will be displayed at the Blynk interface is pH level, water level, temperature of water and water pump alarm system.

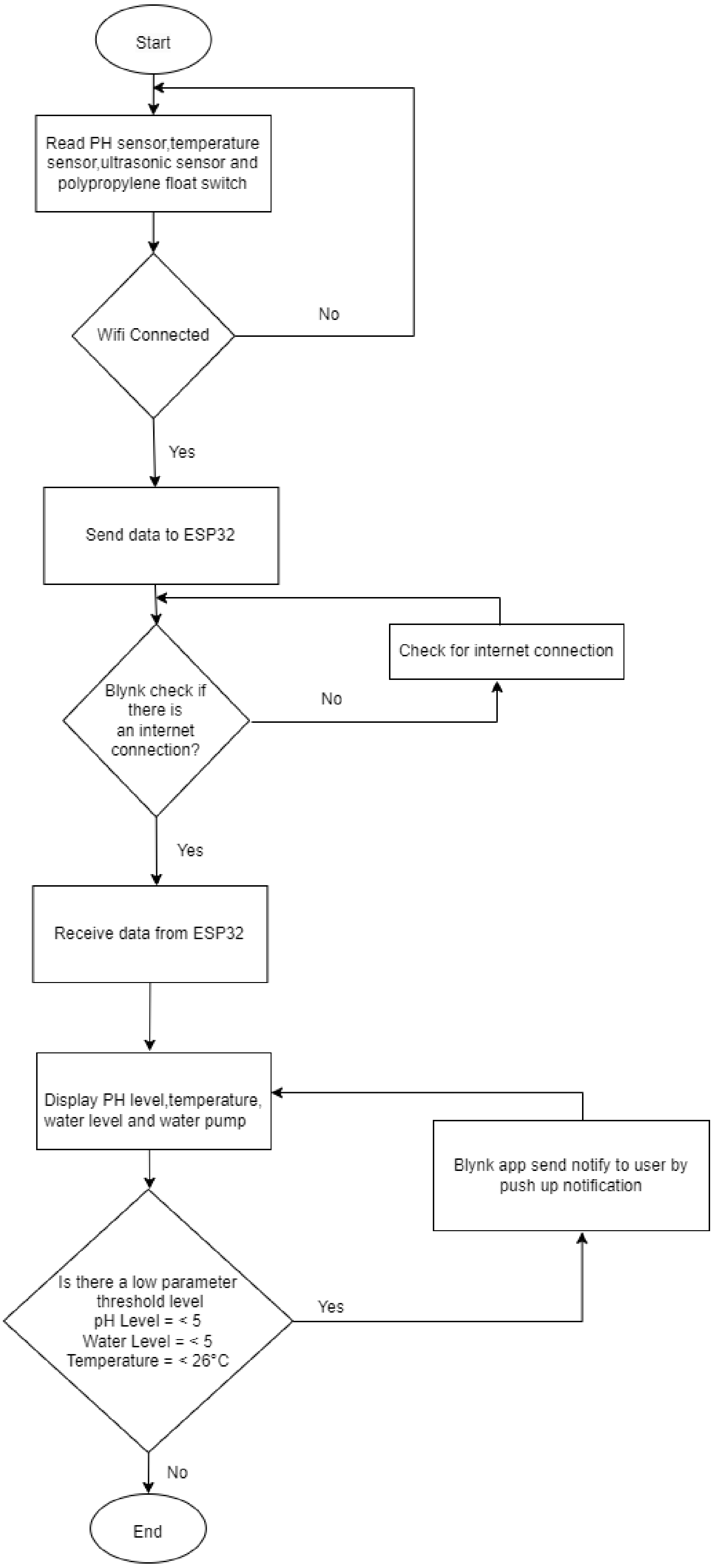

Figure 2: The operational flowchart of the system

2.2 Methods

Figure 2 indicates the flowchart for the system design. First, the sensor will collect measurement data from the aquaponic fish tank such as water level, pH level, temperature of water and water pump, and send it to the ESP32 if all sensors are connected to the ESP32 with the correct pin. Blynk is a web server and database server. Blynk will read serial data from ESP32 after data sensors are sent by ESP32. When data is successfully read, data sensors are saved in the Blynk and the data can be monitored on any electronic device. When a low parameter threshold level is detected, the Blynk app notifies the user via push notification on a mobile phone.

3. Results and Discussion

3.1 Water Pump

The installation of a polypropylene float switch probe, as shown in Figure 3, is performed to serve as a means of verifying the proper functioning of the water pump. The polypropylene float switch is designed to detect the water level in a tank or container. When the probe is touched by the rising water level, it indicates that the desired level has been reached and the pump is working properly. The green button state is displayed on Blynk to inform the user that the water pump is properly functioning.

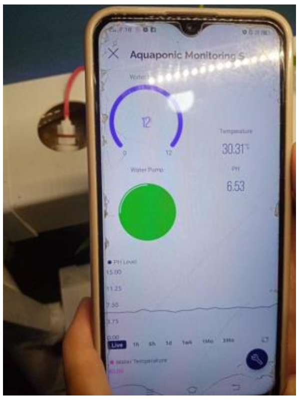

Figure 3: The green button state is shown on Blynk for the polypropylene float switch.

When a malfunction or power failure causes the water pump flow system to stop, the decreasing water level should be responded to accordingly by the polypropylene float switch as shown in Figure 4. An alarm notification in the Blynk application on the phone is triggered by the system and sent to designated users. This action confirms that the water level changes are being accurately and properly detected by the polypropylene float switch. The red button state is displayed on Blynk to inform the user that the water pump is not working.

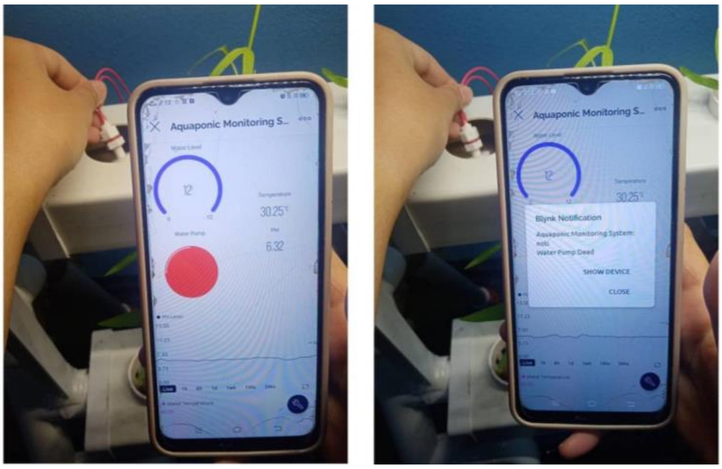

Figure 4: Water pump sensor monitoring alarm notification

3.2 pH level

Figure 5 shows the result for pH level from the Blynk dashboard. In this work, the pH range for aquaponic systems is around 6.8 to 7.0 [5]. To maintain the pH level in an aquaponic system, regularly test the water using a pH testing kit or meter. It is essential to identify and adhere to the ideal pH range for fish and plants, making necessary adjustments. Moreover, maintaining good water quality through oxygenation and temperature control is crucial for a thriving aquatic environment.

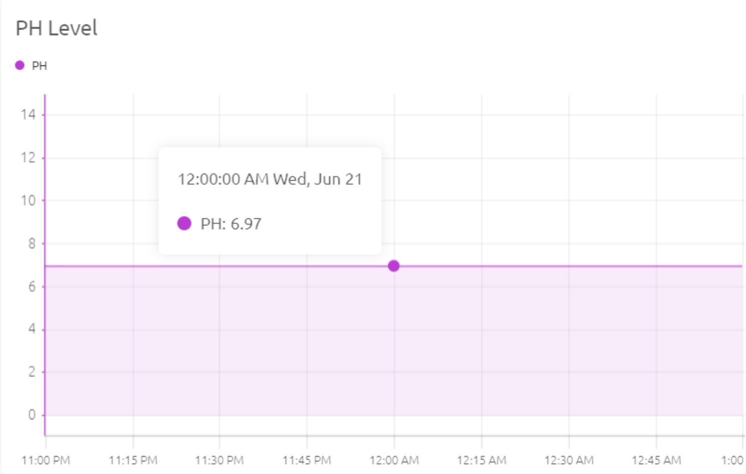

Figure 5: Result for pH level from Blynk Dashboard

3.3 Water temperature

Monitoring water temperature within an aquaponic system holds immense significance due to its direct impact on the overall health and well-being of both plants and aquatic life. Figure 6 illustrates a graph displaying water temperature data retrieved from the Blynk dashboard. In the context of this work, the recommended water temperature range for optimal aquaponic system performance falls within the range of approximately 25°C to 30°C. It's worth noting that aquaponics typically thrive in a temperature range of 68°F to 86°F (20°C to 30°C) [6], which is conducive to the well-being of bacteria, plants, and fish. Selecting the right combination of fish species and plants tailored to your specific location and environmental conditions is crucial to prevent issues and minimize maintenance expenses. Furthermore, while some fish and plants may exhibit tolerance to a broader temperature spectrum, significant deviations from the ideal temperature range can potentially impact growth and overall productivity.

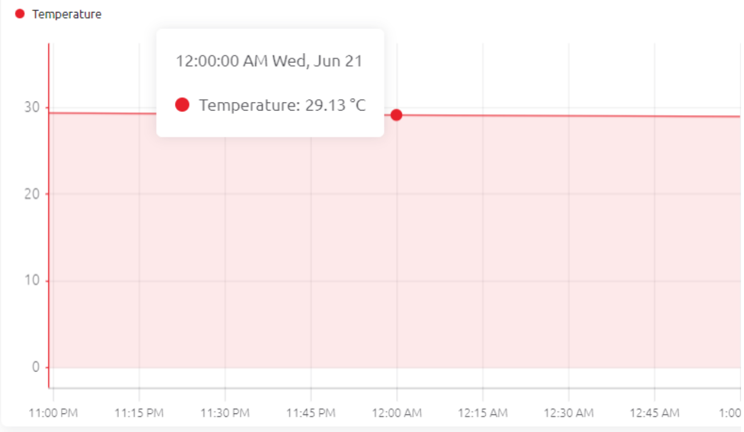

Figure 6: Result for water temperature from Blynk dashboard

3.4 Water level in the fish tank

Figure 7 shows the fish tank's water level 12 litres of water were added to the fish tank. Several factors can contribute to a decrease in water level in an aquaponic system. Evaporation is a natural process where water turns into vapour and escapes into the atmosphere. Absorption and transpiration by plants, as well as the water intake of fish, can also lead to water loss. Leaks or drips in the system, faulty drainage or overflow mechanisms, and inadequate plumbing connections can result in water escaping the system. Monitoring the water level regularly, implementing covers or insulation, optimizing plant density, repairing leaks promptly, and ensuring proper drainage and overflow systems can help mitigate these factors and maintain a stable water level in the aquaponic system.

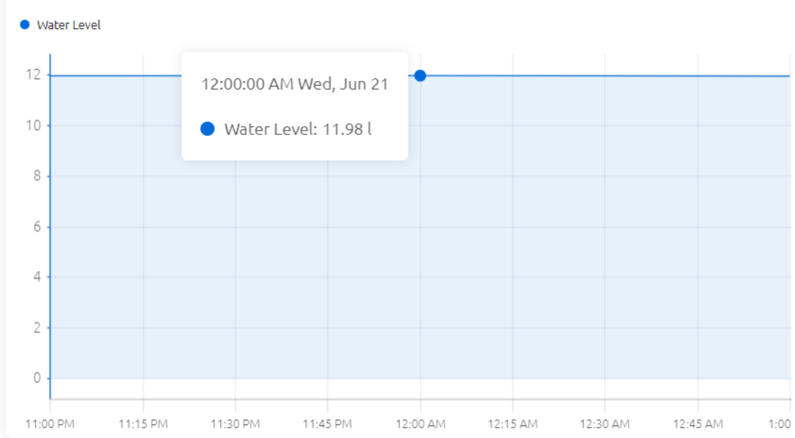

Figure 7: Result of water level from Blynk dashboard

3.5 Plant morphology comparison between aquaponic and hydroponic

Two popular ways of growing plants without soil are hydroponics and aquaponics. While these two systems have some similarities, there are significant differences in the way plants grow and their overall morphology. Here's a comparison of plant morphology in hydroponics and aquaponics in the evening and on the 30th day.

Table 1: Comparison between hydroponic and aquaponic

Part	Aquaponic	Hydroponic
Leaf	The leaf's tip is smooth and tapered like an arrowhead. The leaf measures 3.2cm to 6.4cm in length by 0.7cm to 1.1cm broad. The bright green leaves grow alternately.	The leaf's tip is smooth and tapered like an arrowhead. The leaf is 13cm to 15cm long and 4cm to 6cm broad. The bright green leaves grow alternately.
Stem	The stem measures 29cm in length. The stems are readily shattered. It expands vertically.	A 30cm to 35cm long stem. Stems are readily damaged and delicate. It grows vertically and creeps.
Root	Root measuring 2.5cm in length. The colour of the root is greyish-white.	A root measuring 10cm to 12cm in length. The colour of the root is greyish-white

There is a distinction between hydroponic and aquaponic plant development, as seen in Table 1 and Figure 8. The leaf, stem, and root are all various sizes. Growers can accurately manage the nutrient composition of the water in hydroponics, ensuring that plants receive enough levels of all-important nutrients. Aquaponics uses the waste produced by the fish in the system to feed the plants. While fish waste includes essential nutrients, the availability and balance of these minerals might fluctuate, potentially leading to shortages or imbalances that limit plant growth. To facilitate larger plant growth in an aquaponic system, several key factors should be considered. Firstly, optimizing nutrient availability is crucial. Ensuring a well-balanced nutrient profile, particularly with sufficient nitrogen, phosphorus, and potassium, promotes robust vegetative growth and stronger root systems. Additionally, monitoring and maintaining appropriate pH levels (typically slightly acidic to neutral) ensures optimal nutrient uptake by the plants. Adequate lighting is essential for photosynthesis, and providing the appropriate intensity and duration of light supports healthy plant growth. Controlling temperature and humidity within optimal ranges for the specific plant species further facilitates larger growth. Proper aeration and oxygenation of the water, as well as ensuring efficient water circulation, are vital for root health and nutrient delivery. Finally, selecting appropriate plant varieties that are well-suited for aquaponics and have the potential for larger growth can contribute to achieving desired plant sizes in an aquaponic system. By addressing these factors and providing favourable growing conditions, plants in aquaponics can thrive and achieve substantial growth.

Figure 8: Comparison between hydroponic(left) and aquaponic(right)

3.6 Discussions

The results showed that the sensor data varied depending on the environment, demonstrating the sensor's functionality. Additionally, the Blynk graph demonstrates that the entire ESP32 data set was successfully transferred to the Blynk IoT, which offers an aquaponic farming real-time monitoring solution. As a result, the graph from the Blynk can be used to monitor and analyse all the parameters for the monitoring system, including the water pump, pH level, water level, and water temperature. Thus, this work will assist users in maintaining the hydroponic system's ideal pH, water pump, temperature, and water level.

4. Conclusion

In conclusion, the aquaponic monitoring system based on IoT could help to reduce user burden while providing accurate statistics and analysis. Furthermore, as an online system, the system can provide users with immediate access. The system offers real-time monitoring and data collecting by integrating a variety of sensors, including pH, DS18B20 waterproof sensor, ultrasonic sensors and water pump for water level monitoring. It also incorporates an ESP32 microcontroller and the Blynk IoT platform. The system also allows users to receive notification alerts on a mobile device. In this work, the pH value was measured at 6.97. Meanwhile, water temperature maintained a range of approximately

29-30 ºC. Additionally, the water level was carefully regulated at 12 litres, ensuring sufficient circulation and coverage for plant roots while accounting for any potential water loss due to evaporation. The convenience of the system is expected to increase productivity and reduce water usage in the agriculture field. It also encourages traditional farmers to practice environmentally friendly aquaponic system farming and provides a better farming experience to all users.

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