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Indoor Smart Aquaponics Monitoring System using Raspberry Pi based on Internet of Things

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Abstract: This paper presents a study conducted to provide an innovative, resource-effective and urban-suitable solution through the development of a Raspberry Pi based on a Smart aquaponics system made self-sustainable by wireless Internet of Things (IoT) monitoring and automatic feeding system. The common issue in the modern world is the food crisis. Many citizens barely afford food and vegetable due to rising prices because of the scarcity of water and land. The advantage of aquaponics is saving more space and less water change required which is purely organic. Thus, it is a recirculating water system for fish and plants, requiring technical knowledge and more start-up cost to build aquaponics. Water is the lifeblood of an aquaponics system. The aim of this project is to monitor and analyze water quality. A good quality, nutrient-rich water provides a good environment for the bacteria to thrive and nitrify to keep the water safe for the fish. With the help of monitoring support, action can be taken before things goes worse, a lot of trouble can be avoided and no worry about time and effort for close-monitor fish and plants. The system involves three detections, namely pH level, water level, and temperature sensor using a Raspberry Pi 4 microcontroller. Also, a relay has been used for grow light controlling features which are flexible and capable grow aquaponics indoors. This monitoring will adapt IoT features Blynk application on the smartphone which is able to check the status in the aquarium through wireless and store this data in the Firebase cloud server as a database. The core of aquaponics is nitrogen recycling it starts with ammonia as decomposing and is produced by fish also a natural nutrient for the plant. In case the sensor detects of unaware situation, the system will alert notification the owner through telegram once triggered sensor's value threshold. This project collected reading data for three weeks and recorded it at Firebase Cloud. Based on the analysis, the temperature of water recorded in the past three weeks is between 26 ˚C to 29 ˚C: the pH level value recorded in the three weeks are between 5.9 to 6.5; the water level sensors recorded in the past three weeks, the water has reached to 0 of water level detect bar.

Keywords: Aquaponics, Water quality, IoT

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1. Introduction

Aquaponics is receiving growing interest as an emerging technology that combines recirculating aquaculture practices and hydroponics to produce fish and vegetables [1]. Aquaponics is a rising technique of native food production, employing closed integrated with minimal input because of recirculating aquaculture systems (RAS). Traditional farming was using soil quality, pesticides water, chemical fertilizers and climate conditions. The medical problem arises when farmers do not concern about minimizing organic wastes to suit the environmental carrying capacity and refrain from harmful chemicals [2]. Several researchers had planned numerous strategies for maintaining the balance of systems within the aquarium and also the plant. This system is designed for indoor also as well as outdoor systems. Sensor reading will be further used for analysis purposes.

Human activities, degraded land, water, environmental, social, and economic problems have increased consumption by increasing the population [3]. Agriculture has provided the foremost of the population with natural food however today the employment of pesticides has been increased for quick growth of the crops as a result of that it's caused harm to human health and also the issues associated with soil also increased within the past few years. As a result of that, we've got introduced an aquaponics system for the expansion of the plants naturally with the assistance of fish extract. At the same time, the need for high efficiency in the use of water and other resources is also mandatory. Plant-derived products are among the most important challenges we face in our daily lives and industrial processes, because of the high requirements and demands of food, feed and raw materials [4]. Space efficiency is usually a concern with growing as a step-at-home, and aquaponics is able to be vertical grow to almost any scenario [5].

In this project, the aim of the prototype focuses on recent development in soilless farming, hydroponics and aquaponics making it feasible to farm at your own house or farmer. Besides, the system was designed automated to reduce most of the manual work of farming and having in the natural growth of plants. The extract includes both ammonia and nutrients required by plants, it was useful in the development of a system that combination of two. In fact, the system eliminates the use of chemicals and other fertilizers. Information obtained from the cloud will give accurate readings to the system. The system presented in this paper aims to highlight soilless farming with help of plants.

2. Materials and Methods

In Figure 1, label 1 waterproof temperature as DS18B20 temperature sensor used for measuring water temperature between -55 to 125°C with ±0.5°accuracy. pH level sensor is used to measure the acidity or alkalinity of the water. The water level sensor used to trace the change in resistance corresponds to the distance from the top of the sensor to the surface of the water. In label 2, Raspberry Pi 4 is a central process unit used to connect Wi-fi and program code for water level temperature sensor, pH level, water level, fish feeder timer with servomotor and grow light led timer. In label 3, Blynk software will be used as the data analysis monitoring for three sensors. The data will be uploaded and stored in Firebase Cloud. The mobile phone will receive a notification if the trigger the sensor value threshold. In label 4, the Led grow light timer will turn on 12 hours per day. A fish feeder with a servo motor is active every 12 hours per feed.

Based on Figure 2, the project interfaces Raspberry Pi with sensors using python language. The coding will be uploaded into Raspberry Pi and read the value in the Blynk application. The Raspberry Pi connected to a local Wi-Fi server allows the transfer of data output received from the sensors to the Blynk application while also uploading to the Firebase. Any action such as led timer on or off or servomotor activation will be recorded at the firebase cloud according to the time and date. The telegram will notify warning users if the sensor detects a low value for pH value set point is below 5, for water level is below 200 resistances, and for the water temperature sensor is below 25˚C. The design of

aquaponics is shown in Figure3. The fish tank size is a total of 480 mm in width and 270mm in length including a cover of wiring components. The water cover half of the fish tank.

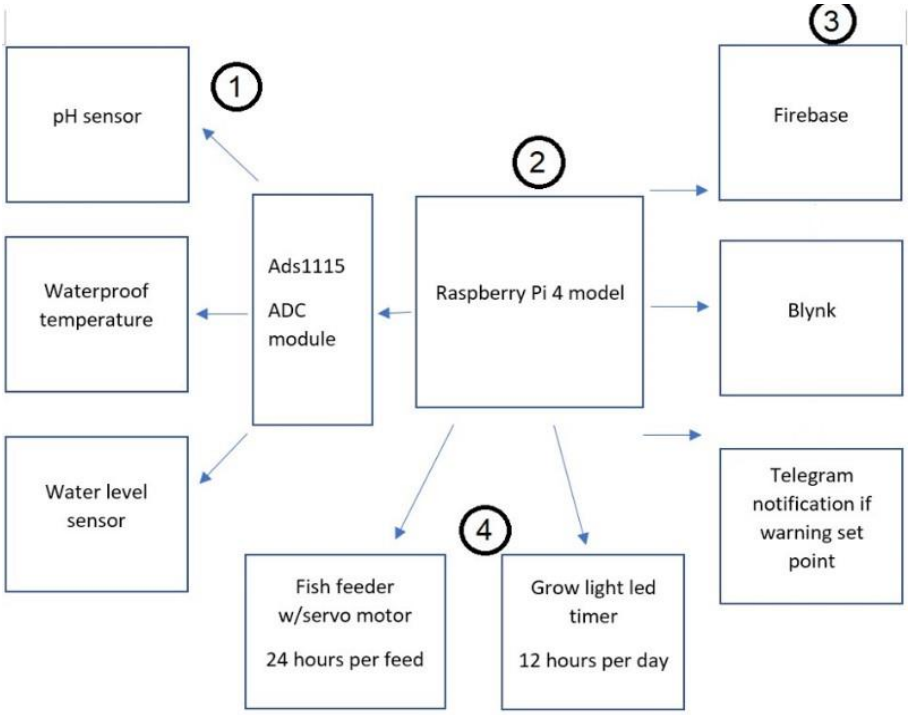


Figure 1: System design block diagram

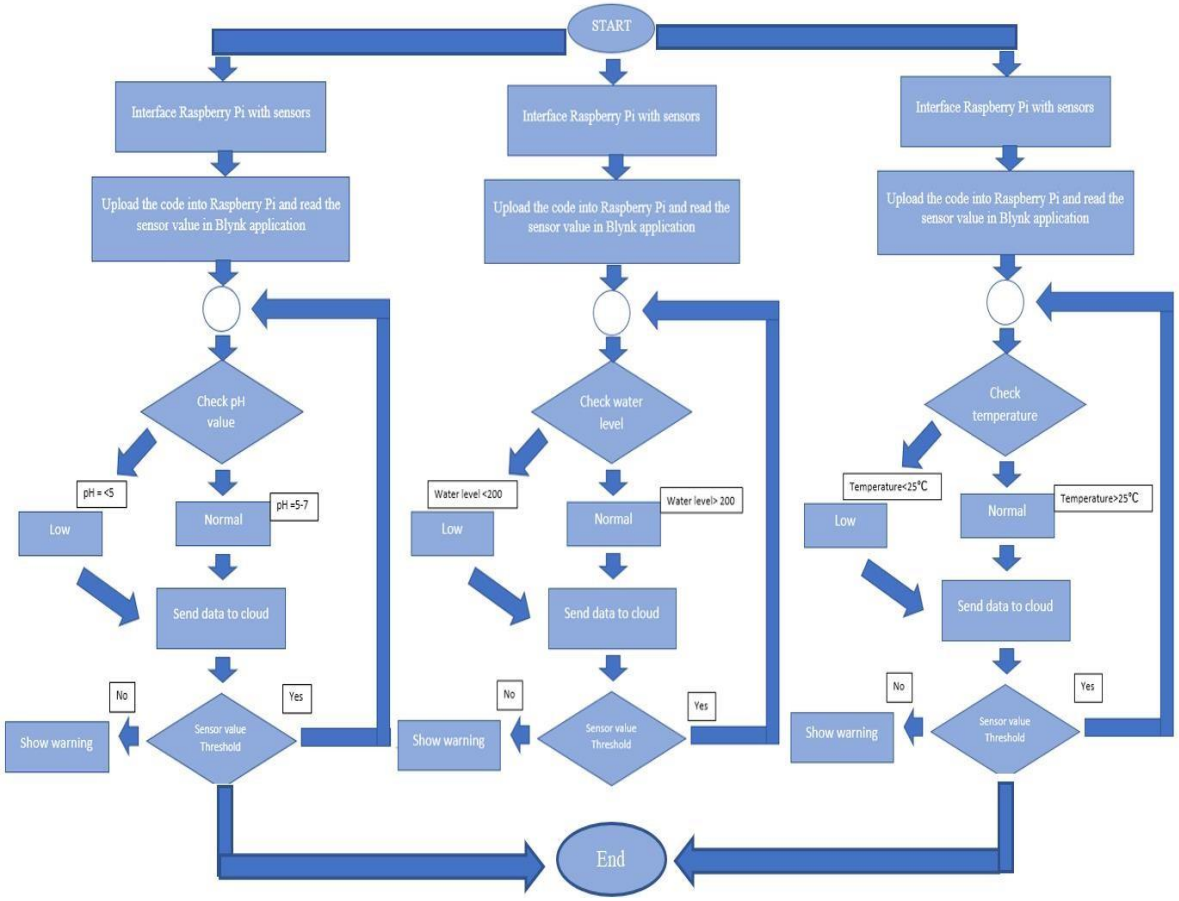


Figure 2: Flowchart of the system

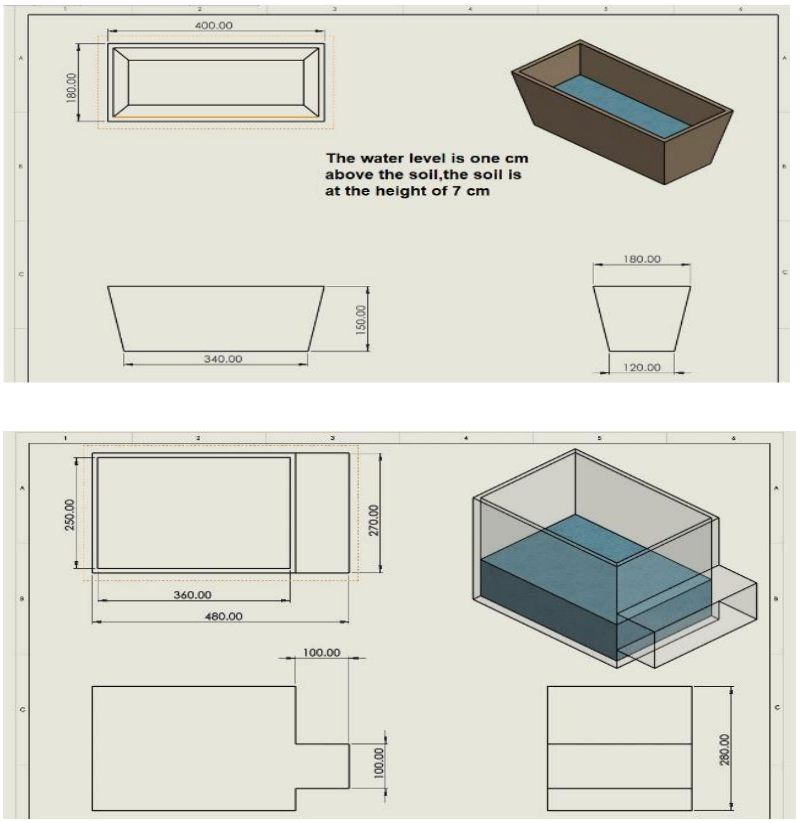


Figure 3: Plant bucket and Fish tank

Figure 4 shows the telegram notification when the water level sensor detects a low level in the water tank. To determine the condition of the water in the tank, the registered parameter by sensors is detected for pH level, water level and temperature of the water. The sensors read the value and provide the information to the registered users through wireless. The interval time of sending a message is twenty seconds based on the sensor reading time. Any critical value will inform users through a telegram to replace the water or take necessary action.

Figure 4: Telegram bot notification

Figure 5 shows the Blynk application monitoring the real-time data online that is connected to the internet. The Blynk was designed for the Internet of Things. The Blynk app has been developed that presents data from the water tank to the user interface. It can control hardware remotely, for this project is control grow light led and fish feeder servomotor. Besides, it can display sensor data, it can store data and visualize it. More features will require us to pay for multiple functions after reaching its free trial limit. With wireless installations, the users do not need extra cost to buy an LCD to display the sensor data or installation of cables. After connecting to the internet, the user is able to monitor and control the condition of the hardware through a smartphone equipped with the Blynk application. A relay has been used for grow light controlling features that are flexible and capable grow aquaponics indoors.

Figure 5: Blynk application monitoring

3. Results and Discussion

In Figure 6, the data were extracted as Json. file into Microsoft Excel from Realtime-Database. For water level monitoring, the water drains slowly from 600 to 300 resistance. The readings were taken over two weeks to monitor the change in water level. The suitable range of temperature for plants and fishes in the system is between 25 ˚C - 30 ˚C. The readings were taken between 24 hours to monitor the change of temperature in a day. The suitable pH range for the plants and fishes in the system is between 6 – 7.5. The readings were taken for seven days and the system is in a healthy range.

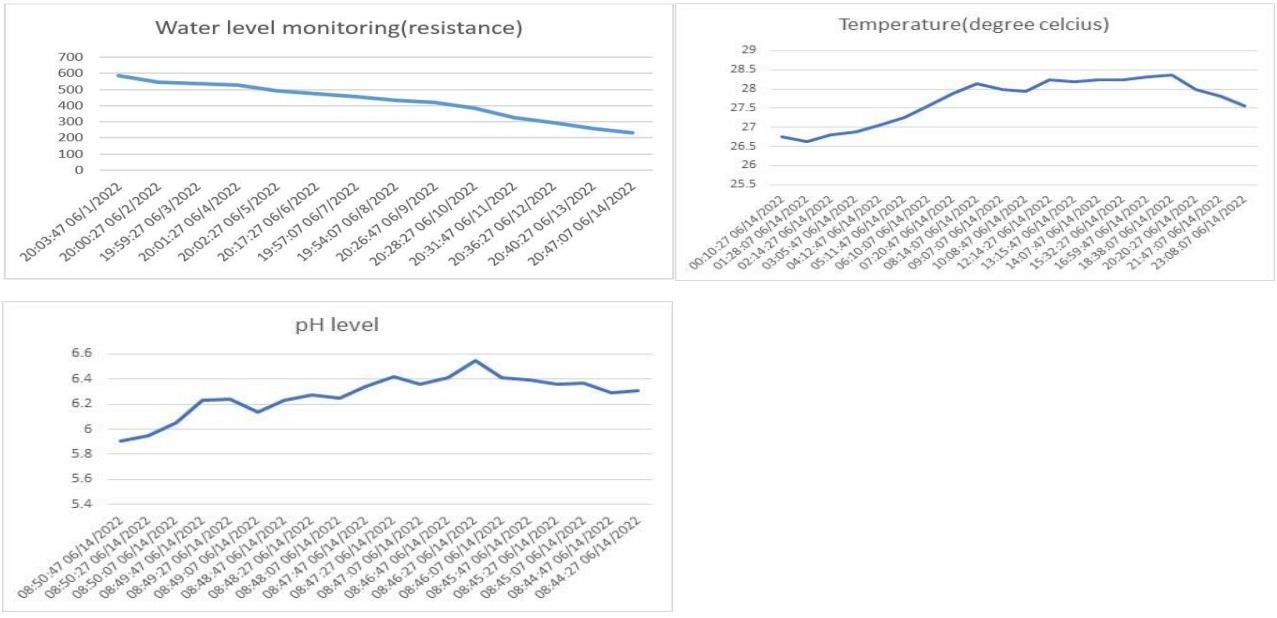


Figure 6: linear regression graph from Microsoft Excel

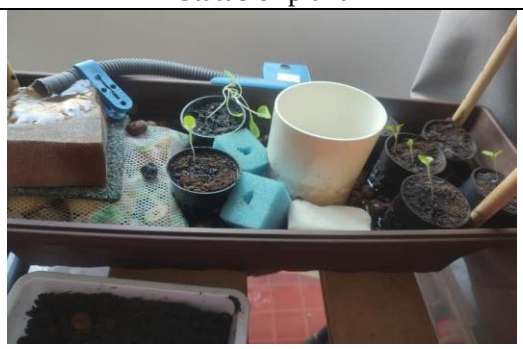
Figure 7 shows the basic prototype before the installation and after installation. The water pump absorbs water to the top layer carried out nutrient to the plant and then refresh the clean water back to the fish tank. The fish tank size is 12x6x6 inches. The prototype of an aquaponics system is designed to monitor with three sensors are temperature sensor for measuring temperature, and pH level for measuring the acidic level of water which is important information to know that fish is in a safe condition, and a water level module for measuring water level to know the amount of water in a fish tank because the water vaporizes quickly, especially in the small water tank which farmers have to pay attention on a certain case.

Figure 8 shows the fish when purchased by day 1 and after 1 month. The fish are fed twice a day. The fish tank is full automate feeding and was never been cleaned during the experiment. The 10 goldfish were all alive after the end of the experiment. The observation of the lettuce plant is shown in Table 1 from 3 to 21 days.

Figure 7: Observation before installation of the circuit and after installation

Figure 8: Observation of the fishes by day 1 and the end of the experiment

Table 1: Lettuce growth over time

Time		Status of plant
Day 3	At the beginning of the operation of the setup, six cups of lettuce were grown from seed. About three days after being planted in the containers at the window, the healthy lettuce plant is growing with one leaf branching out.	
Day 7	After just seven days, the immense growth can truly be seen in the plant sprouted largely and now resembles a bush or shrub with many different branching stems and leaves.	
Day 14	Surprisingly, lettuce grows fast and sprouts more leaves. But the stem is not strong enough and the leaves are taking more burden on it. The plant does not look good.	
Day 21	Lettuce grows slowly compared to before. The leaves grow bigger and the plant looks healthier.	

4. Conclusion

The water quality is the reason that plants and fishes stay healthy that is why the monitoring system is important. The wastewater has to be continuously analysed and purified in order to make it clean water. The project aims to analyse several parameters like water temperature, water level, and pH level. To purify the water, farmers need to satisfy plant requirements which is light to stay alive that is the

reason the LED timer has been utilized. By adding the fish feeding timer function, the farmers are able to leave close monitoring for about one or two weeks. The proposed system is based on the threshold values set, Raspberry Pi notifies the registered user by sending telegram notifications with values and these values are retrieved through a cloud server. Besides, on the Raspberry Pi application runs connected to the local internet network, the smartphone is able to see on the widget of sensor reading and also turn on LED or servomotor manually. Based on the analysis, the temperature of water recorded in the past three weeks is between 26 ˚C to 29 ˚C: the pH level value recorded in the three weeks is between 5.9 to 6.5; the water level sensors recorded in the past three weeks, the water has reached to 0 of water level detect bar. This project also encourages the traditional farmers to practice aquaponics which is environmentally friendly and also provides a better farming experience to all users.

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