International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Design and Development of Automatic Hydroponics Using Iot with Data Logging

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Abstract

The method of cultivating plants using a nutrient combination is called hydroponics. It is a fantastic method for maximising plant growth. At the moment, installing a hydroponic system necessitates studying the plants that will be cultivated. Plants are cultivated in a controlled environment using the developed automated hydroponic system, which is based on the nutrient film technology (NFT). Every week, it immediately injects a nutrition solution into the watered roots of plants. The water pump continually circulates the mixture of water and nutritional solution. Hydroponics method utilizes less fertilizer and water than a soil-based system. To provide a consistent supply of nutritious solution, this system uses relay and alarm ideas that are coupled to the microcontroller. The main goal of this research work is to build an IoT-based hydrophonc system that will improve system reliability and allow for remote parameter administration and monitoring.

Keywords: IoT, Hydroponic, DHT11,

1. INTRODUCTION

The agricultural technique known as hydroponics relies on growing plants in solutions containing minerals. In practical world, it is a method of growing plants in a nutrient rich solution without soil. Soil is not necessary for growth of plants; it is only an early form of production that has been part of the global crop history [1], [2]. Only the nutrients are contained in the soil, which also serves as a basis of support for the structure of the plant and is where plant roots normally reside [3]. Although the word "hydroponic" literally means "water working," it refers to a technique for growing crops without the need of soil or with the use of an inert medium that contains all the necessary nutrients. Fresh veggies may be effectively planted using this method, not just in areas with limited arable land but also in smaller areas. The enhancement of product quality especially in vegetable crops like tomato, cucumber, lettuce etc. can be achieved by controlling the supply of nutrients in hydroponic. In this technique, it was hoped to reproduce the natural conditions of growth as same as in the artificial system [4]. The primary goals of hydroponic farming are to obtain maximum output through the provision of enough, high-quality nutrients and ideal microclimatic conditions. Fertile soil is not necessary for hydroponic cultivation. Furthermore, since soil is not used in the manufacturing process, problems with weeds, pests, or illnesses carried by the soil will not arise. The absence of these issues means that no toxic plant protection agents will be used, resulting in a fresh and healthy output.

In hydroponic gardening, a growth medium serves as the plant's support system and absorbs the nutrient solution in place of soil [14]. Plant roots are normally found in the soil. The soil helps plants grow and finds food and water for them. A hydroponic plant's roots do not have to work as hard as those of a soil-grown plant since the nutrient combination easily satisfies their demands. Rockwool, hydro corn, coco fibre or chips, Perlite, Vermiculite, Oasis cube, floral foam, poly foam insulation and rice hulls are a few growth media used in hydroponic farming. It is also necessary for the growth medium to be chemically inert and readily cleaned and drained.

2. RELATED WORKS

A model by Saaid et al. uses a pH sensor to automatically adjust the pH value. The sensor measures the amount of water and nutrients in the reservoir, and it uses a solution mixer in a valve to maintain the pH level at the required level [2]. Through level control, which activates a valve to regulate water flow into or out of the reservoir, the water level in the reservoir is continually maintained. According to Saaid's suggested experimental setup, 5.64 ml of variations in the range of acidity and alkalinity are required for every 0.312 and 0.244 pH.

In a study conducted by Saaid et al., the growth performance of aquatic comet goldfish was compared to that of a hydroponic plant of the leafy vegetable type Ipomoea aquatic (also known as water spinach). The effectiveness of the aquaponic system's recirculation with regard to temperature, light, and fish waste was also assessed [4]. Commercial pelleted feeds with 30% crude protein, which may supply nearly all the nutrients needed for plant development, were fed to the fish. This system has an auto feeder in place to keep growth and survival rates stable. Water filtration systems are used to reduce the quantity of debris and breakdown products present. A set point in this system is the required value that the user wants. Arduino, on the other hand, acts as a brain that processes data from sensors and generates instructions for a response or action as feedback. The actuator's response to the act received will then determine the course of action.

According to research by Ali et al., a microcontroller automatically maintains the pH level in a water solution while a sensor measures it [11]. The capacity of the system to modify the pH of the water solution for deep water culture (DWC) is another major focus of this research. To continue growing the plant, the water solution from the DWC container is moved to the main tank, where a sensor measures the pH level and any necessary adjustments are made before returning the water solution to the DWC container. According to the results of the trial, the system can raise or lower pH by 1.15 and 0.58 pH, respectively.

Cucumber seeds put in a low-temperature environment and stimulated by 2.45 GHz, 50 W microwave illuminations were shown to germinate by Tani et al. [12]. A microwave heating system, air conditioning system, light emitting diode (LED) lighting system, and data logger system for measurement are assembled into a system. A signal generator produces 2.45 GHz microwaves, which are then amplified by an amplifier to a maximum of 50 W in the microwave heating system. Finally, a microstrip patch antenna placed close to the target plants radiates amplified microwaves. To regulate the temperature, an integrated spot cooler is used. There is a 15 W LED panel utilised for LED lighting. Video cameras, hygrometers, and computer-aided thermometers are ready for the measuring system.

The effects of light quality on the development and quality of hydroponically grown lettuce were discovered by Chen et al. [13]. White LED was used as the control (CK), followed by white-red LED (R:W=1:4) (T1), and red white LED (R:W=1:1) (T2). The radiation lifetime of the photosynthetically active radiation (PAR) was 6:30–18:00, with a PAR of 150 micron mol.m-2s-1. The lettuces were cultivated for 35 days under various light conditions. The findings demonstrated that light quality treatment had a major impact on lettuce growth and quality. Red light promoted the growth of the shoots and roots in hydroponically grown lettuce, and this growth increased as the percentage of red light rose. In the T1 and T2 treatments, the fresh weight of the shoot grew by 34.6% and 52.7%, and the fresh weight of the root by 46.9% and 97.8%, respectively. Therefore, in a hydroponic system, more red light promotes better lettuce growth and quality.

Changmai et al. conducted research to examine the advantages of a smart hydroponic farm produced with IoT technology over a conventional hydroponic farm. The crop used for testing was lettuce [18]. This smart farm has the ability to autonomously monitor the growth environment and modify the fertiliser solution, air temperature, and air humidity based on the conditions. According to the findings, lettuce from smart farms typically weighs 36.59% more, has 17.2% more leaves, and has a wider stem diameter (13.9%) than lettuce from traditional farms. Additionally, smart farm lettuces had an 8.24% higher nitrate level.

Peuchpanngarm et al. implemented the fully automated greenhouse management system using low power wireless components and also showed how the system can be resumed if encountered with an error [19]. The basic algorithm behind the developed system is that if problem detected than message will be delivered to the owner and the system will wait for further instructions; these instructions can be conveyed (a) manually, using the hardware present at the location (b) remotely, using smart message service. At the end, the author concluded that - the developed system can handle the famine problem around the globe smoothly and efficiently along with increment in the production and protection of crop.

An investigation on the impact of nutrient solution pH and nitrogen form on the phosphorus and nitrogen concentration of spinach shoots in hydroponic lettuce was carried out by Najafi and Parsazadeh [31]. The findings demonstrated that the content of phosphorus and nitrate in the shoots dropped when the pH of the nutrition solution was raised from 4.5 to 8.

Gomes et al. observed that three melon varieties did not differed significantly in their growth characteristics like plant height and leaf number in nutrient uptake (uptake of N, P, K, Mg and Zn) when grown hydroponically using nutrient solutions with five different pH levels [32]. Baevre studied the comparision of fruit quality of tomatoes grown in soil and in a nutrient solution [33]. In this study, when compared to soil, tomato cultivator yielded fruits with high total dry matter, soluble dry matter, total sugars under NFT.

3. SYSTEM METHODOLOGY

This research has been done to design a good hydroponic system without use of soil. This system will give better result by providing nutrient solutions directly to the root of the plants automatically. Figure 1 shows Block Diagram.

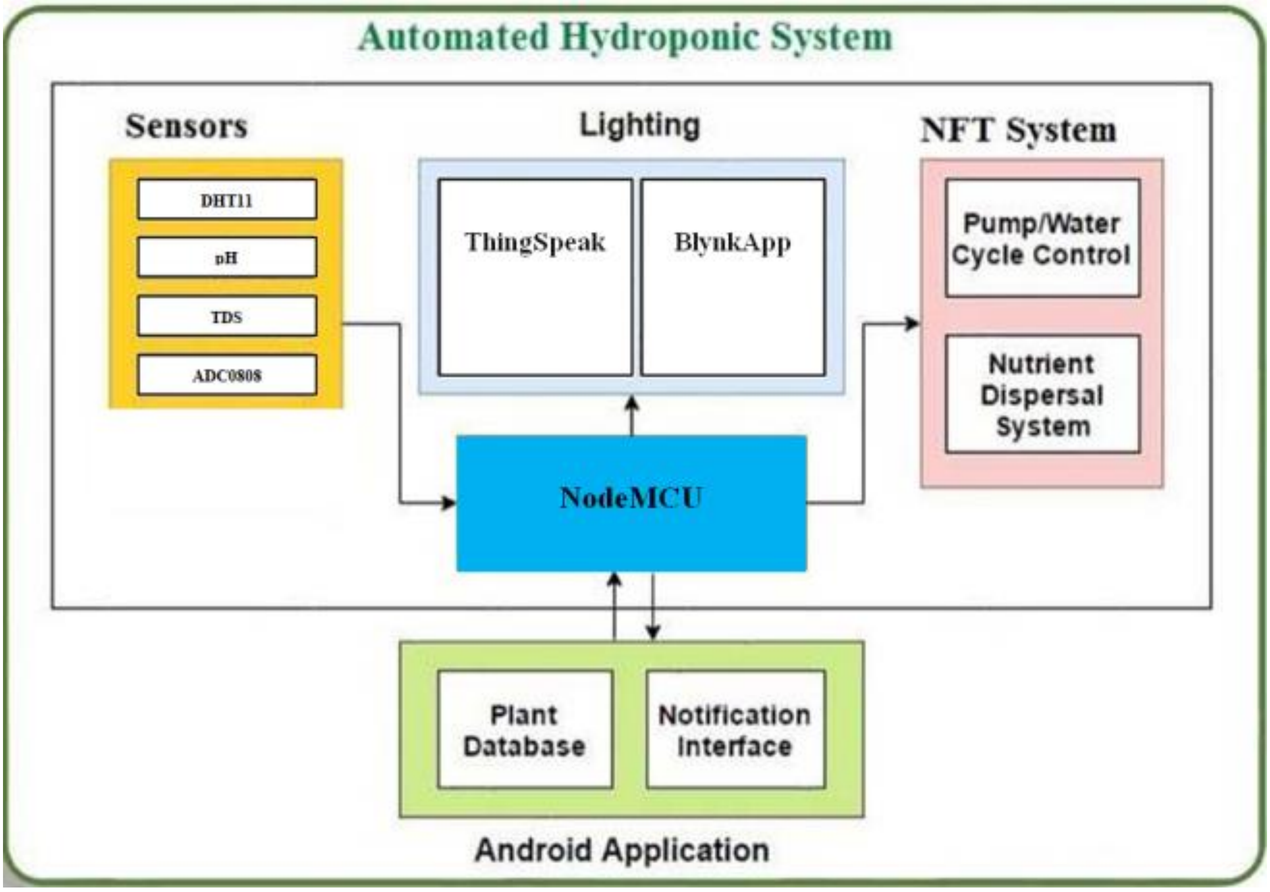


Figure 1 Block Diagram

Power Supply

Solar panels provide the electricity needed to run the constructed hydroponic system. It takes 20 W of generation to run this system. In order for the microcontroller to have access to a consistent power source even when the panel is not in direct sunlight, a 12 V battery stores energy. When the battery is completely charged, the system can operate for at least a day. In order to do this, a solar panel has been placed, and it will provide the electrical components with electricity. These photo cells would provide electricity during the day to drive the numerous 12-volt DC equipment and the LED array required to grow the plants. The microcontroller and sensors would therefore require lower voltages from this 12-volt power source. The extra power would be kept in reserve in a battery bank, allowing the system to run all night and on cloudy days when there is little light.

DHT11

The DHT11 sensor is a simple and effective way to measure temperature and humidity in a variety of automatic systems. It provides a digital output of the temperature and humidity measurements. Creating an automatic hydroponics system using IoT with data logging can greatly enhance the efficiency and effectiveness of managing plant growth environments. The DHT11 sensor plays a crucial role in this setup by providing real-time data on temperature and humidity, which are essential for plant health. Connect the DHT11 sensor to the microcontroller to read temperature and humidity. For Arduino, connect the data pin of DHT11 to a digital pin.

pH Sensor

In a hydroponic system, maintaining the correct pH level is crucial for optimal nutrient absorption by plants. A pH sensor integrated with IoT can provide real-time monitoring and logging, enabling automated adjustments and remote management. By logging data to an IoT platform and implementing automated control logic, you can create a robust, self-regulating hydroponic setup. This ensures that plants receive the right conditions for optimal growth, leading to better yields and healthier plants. Prior to introducing the young plant into the system, the pH of the water can be adjusted by measuring the pH. In order to translate the data that the sensors receive into pH and EC values, the EC and pH probes are linked to a transmitter. After adding nutrients, the pH of the distilled water was adjusted to be between 5.5 and 6 from a base value that was near to 7. Since pH depends on temperature, it is essential to measure the pH of the water at constant temperatures. After heating the water to 25°C, acidic and basic solutions were used to change the pH.

Analog TDS Sensor

In the automatic hydroponics system using an Analog TDS (Total Dissolved Solids) sensor integrated with IoT for data logging involves several key components and steps. Connect the TDS sensor to the analog input of the microcontroller. It is used to measure the nutrient concentration in the hydroponic solution.

LCD

In an automatic hydroponics system, displaying real-time data on an LCD can provide immediate feedback on system status, such as temperature, humidity, pH, and EC levels. By combining local display with remote data logging and automated control, to create a robust and efficient hydroponic setup, ensuring optimal conditions for plant growth.

NodeMCU

In an IoT-enabled hydroponic system, NodeMCU can handle data collection from various sensors, control actuators, and log data to an IoT platform.

ADC0808

The ADC0808 is a precision analog-to-digital converter (ADC) with 16-bit resolution. It can interface with various analog sensors, making it ideal for a hydroponics system that requires accurate monitoring of parameters such as pH, EC (electrical conductivity), and water level. Using the ADC0808 with IoT data logging enables real-time monitoring and control of the hydroponic environment. The ADC0808 communicates with the microcontroller using the I2C protocol. It has four analog input channels (A0-A3) that can be used to read multiple sensors. Combine the data from ADC0808 with DHT11 sensors to automate and optimize the hydroponic system.

Blink App

Integrating the Blynk app for an automatic hydroponics system with IoT data logging involves setting up the hardware and sensors, programming the microcontroller to communicate with Blynk, and configuring the Blynk app for monitoring and control. Open the Gauge widget settings and set the range according to your expected TDS values. Open the Button widget settings and set the mode to switch. Open the Label widget settings to display the pump status. Using blink app to indicate the notification widget to set up alerts for abnormal TDS levels or other critical conditions.

ThingSpeak

Creating an automatic hydroponics system with IoT data logging using ThingSpeak involves setting up the hardware, programming the microcontroller, and configuring the ThingSpeak platform for data logging and monitoring.

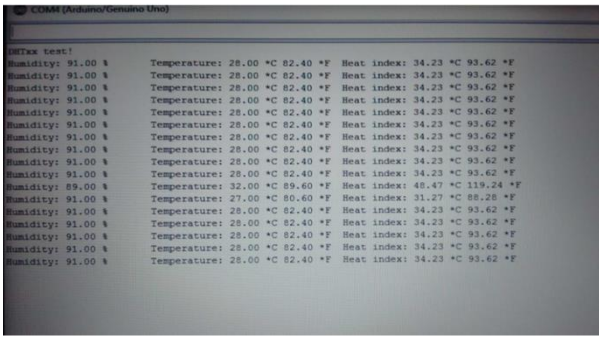
4. EXPERIMENTAL RESULTS

The logs maintained by the Kivy programme were used for data analysis. Every log shows the values that were attained every day and is updated on a regular basis.

Table 1 Soil-based versus automated hydroponic system comparison

Technique for Cultivation (Tomato)	Production (Kg/m²/crop)	Water usage (L/Kg/crop)	Time Duration (in months)	pH (moles/L)	EC (mS/cm)	Temperature (°C)	Relative Humidity (%)
Soil Based System	1.5	450	4	Measurement is not required.			
Earlier Hydroponic System	10	8-10	3	4.4-6.8	1.4-10.4	30-35	34-50 %
Developed hydroponic system	12	5	3	5.5-6	1.2-4.2	25-28	55-60%

Table 1 shows the comparison between the soil based, earlier hydroponic system and developed hydroponic system. When compared to previous hydroponic systems, the created hydroponic system yields a 17% higher overall output. 55–60% relative humidity is kept constant. Diseases may spread more quickly under these conditions if relative humidity rises beyond the set limits. Venting the humid air and substituting it with drier outside air are two ways to reduce relative humidity. High humidity encourages the spread of botrytis and powdery mildew. When compared to previous hydroponic systems, the water usage dropped to 40–50%.



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DHTxx test!
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
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Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 89.00 %	Temperature: 32.00 *C 89.60 *F	Heat index: 48.47 *C 119.24 *F
Humidity: 91.00 %	Temperature: 27.00 *C 80.60 *F	Heat index: 31.27 *C 88.28 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
Humidity: 91.00 %	Temperature: 28.00 *C 82.40 *F	Heat index: 34.23 *C 93.62 *F
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Figure 2 Sensors readings in online sheet

Figure 2 illustrates how the DHT11 sensor's heat index measurements were used to create an online sheet on a computer. Additionally, this data is shown on an LCD screen that is attached to the system. The system may be distant from the computer. Thanks to the Internet of Things and a Wi-Fi module that sent the data, readings on the computer are visible.

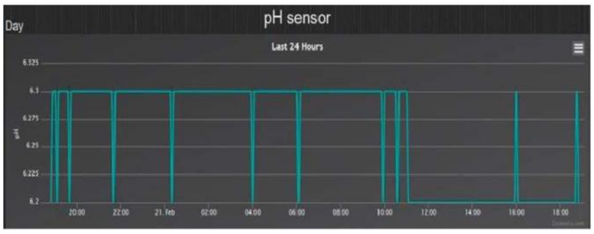

Figure 3 pH readings

As seen in figure 3, pH readings are taken every 24 hours to demonstrate that the pH level is maintained between 6.2 and 6.3. This allows the pH to reach the desired value in the system. By keeping the grower informed about events occurring on site, the automated system that was built enables them to avoid the hydroponic system. Thanks to an Android application, this is now feasible. The user's smartphone receives data. As a consequence, the system is automated as it produces large crop yields even when the farmer is not there. It operates continually.

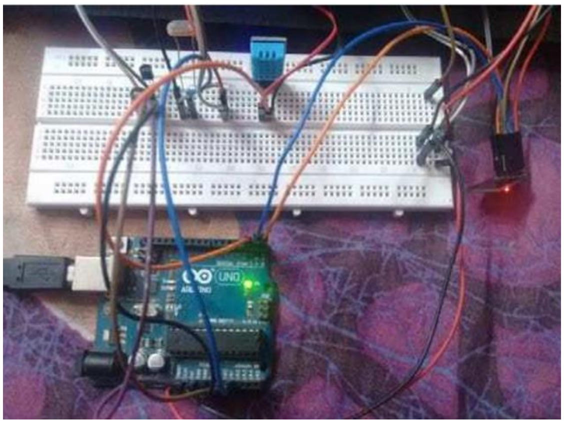

Figure 4 Sensors Connection with Arduino microcontroller

Figure 4 shows the actual image of different sensors connected to Arduino microcontroller. This task was done on breadboard initially.

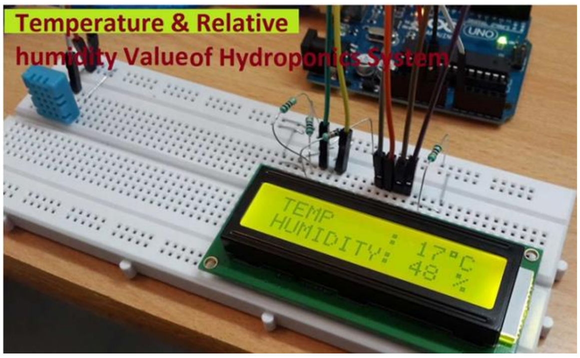

Figure 5 Arduino microcontroller employed in system

5. CONCLUSION

The goal of the proposed system was to provide a low-cost, fully automated hydroponic system that is manageable for the typical user. The IoT technology, NodeMCU, free source software, and a few sensors were used to achieve the goals. The automated hydroponic system was able to integrate an IoT network for remote monitoring and control while maintaining the conditions necessary for the test plant to flourish. The suggested system's dependability is evaluated by comparing it to previous hydroponic systems, developed hydroponic systems, and soil-based comparisons.

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