As per UGC guidelines an electronic bar code is provided to secure your paper

International Journal for Modern Trends in Science and Technology
Volume 11, Issue 07, pages 221-225.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol11issue07.html
DOI: https://doi.org/10.5281/zenodo.16131282

Design of a smart hydroponics monitoring system using an ESP8266 microcontroller and the Internet of Things

Gorapudi Ravi, Navuluri Karthik Reddy, Bygoon Arif, Turaka Hari Gopal

Department of Electronics and Communication Engineering, Andhra Loyola Institute of Engineering and Technology, Vijayawada, India.

To Cite this Article
Gorapudi Ravi, Navuluri Karthik Reddy, Bygoon Arif & Turaka Hari Gopal (2025). Design of a smart hydroponics monitoring system using an ESP8266 microcontroller and the Internet of Things. International Journal for Modern Trends in Science and Technology, 11(07), 221-225. https://doi.org/10.5281/zenodo.16131282

Article Info
Received: 14 May 2025; Accepted: 06 July 2025.; Published: 17 July 2025.

KEYWORDS

ESP8266 Wi-Fi module, Ultrasonic sensor (for water level), DHT11 (temperature and humidity), Solenoid valve, Blynk App (for remote monitoring), TDS sensor, 0.96 Led display.

ABSTRACT

With the rapid depletion of water resources, water scarcity has become an increasingly critical global concern. While rainwater harvesting has been widely explored, the integration of smart technology into such systems remains largely theoretical. This project introduces an IoT-based solution designed to monitor water quality and enhance the efficiency of rainwater utilization. It focuses on a practical approach for collecting rainwater in rural areas, supported by an IoT infrastructure that tracks both the quality and quantity of stored water. Real-time sensor data is made accessible through a dedicated web interface, enabling remote monitoring and management. At the core of the system is an Arduino microcontroller, which interfaces with sensors including water level, pH, and flow sensors. The collected data is processed and wirelessly transmitted to the cloud, allowing for continuous data access and improved decision- making.

1. INTRODUCTION

Hydroponics is a technique of using water and fertilizer solutions as the growing medium, increasing productivity through moni- toring of environmental conditions compared to traditional agricultural methods. In a hydroponic system, plants are kept in tubs, and their roots float in nutrient-rich liquid, allowing them to develop rapidly and become a mass. Hydroponics, which translates to “water work”, comes from the Greek terms hydro, which means “water”, and ponos, which means “labor”. This type of irrigation is frequently used in areas where the soil is not fertile enough to support crop production.

The problem that this study attempts to solve is how to reduce farmers’ efforts in checking the elements that the plant needs without the requirement for farmer intervention. The hydroponics monitoring systems using Internet of Things (IoT) can be em- ployed to reduce losses, optimize efficiency, increase productivity, and lessen the time and effort required. Monitoring the humidity, temperature, salinity, pH, oxygen, and nutritional levels of plants is an important aspect of farming. Smart systems are employed for their convenience, precision, and efficiency brought about by technological developments. This technique has been used to grow fruits properly and has produced good results for larger plants, particularly lettuce, cucumbers, and tomatoes.

The Internet of Things (IoT) is a network of connected computers with mechanical and smart machinery, objects, living creatures, and people. These devices have identifiers and the ability to communicate information with one another and computers without the need for direct human or computer involvement. They can link and interact with others through the web, be automatically evaluated and controlled, and are packed with tools, online networks, and other equipment like sensors. The motivation of the researchers is to apply IoT technology to all areas of daily life and take advantage of these benefits.

The proposed system is novel in that it has the following contributions:

- Farmers can use sensor integration for data-based decision making because the system delivers accurate and continuous measure- ments.
- Farmers can monitor and change environmental parameters remotely because these systems include automation and control components.
- Farmers can evaluate the effectiveness of the hydroponic system because these systems examine the huge quantities of sensor data they receive.
- Farmers can prevent crop loss because the systems may send alarms when specific parameters stray from the appropriate range.
- The systems integrate with other technologies like IoT, are flexible and can be adapted to the particular needs of various crops and growing conditions, and contribute to resource optimization.

Sensors used to build the circuit

The main parts of the proposed monitoring hydroponic system are described as follows.

ESP8266 microcontroller:

The ESP8266 is a low-cost Wi-Fi module developed by Espressif Systems, widely used in IoT applications due to its built-in Wi-Fi and microcontroller capabilities. It features a 32-bit RISC processor with clock speeds up to 160 MHz, and includes 64 KB instruction RAM and 96 KB data RAM. The module supports various communication protocols like UART, SPI, I2C, PWM, and ADC, making it versatile for different types of sensor integration. It operates on 3.0 to

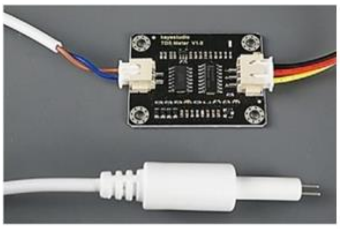
3.6V and includes power-saving modes, which are ideal for battery-powered projects. Popular variants include the basic ESP-01 and the NodeMCU development board, which offers USB support and more GPIO pins.

humidity levels. All the data collected by the

sensors are processed inside the ESP8266 microcontroller before being sent through Wi- Fi to a database to be saved for further use.

Total dissolved solids sensor

The total dissolved solids (TDS) sensor in a hydroponic system is used to gage the concentration of soluble solids in the nutrient solution and expressed as electrical conductivity (EC). It can estimate how much salt dissolves in a liter of water in milligrams by the value of total part per million (PPM), which reflects how pure the water is to a particular level with an accuracy of ± 2% of 999 ppm TDS. The TDS probe and printed board .Measurements during prolonged submersion in water are possible because the probe is waterproof.



DHT11 temperature sensor

This sensor can measure temperatures from

–55 °C to 125 °C with an accuracy of ±0.5

°C. ESP8266 determines and records the signals specific to a particular protocol on its data pin to read the temperature from the sensor. shows the diagram of the DHT11 temperature sensor.

pH sensor

This sensor identifies whether a substance or solution is basic, acidic, or neutral. The sensor can detect pH levels between 0 and 14, with an accuracy of approximately 0.1 pH. Plants require water with a pH between 6.5 and 7; thus, the nutrient solution's pH was maintained in this range shows the applied pH sensor in the hydroponic systems.

Ultrasonic sensor (for water level)

The ultrasonic sensor is a widely used component for measuring water levels in tanks or reservoirs without direct contact. It operates by emitting ultrasonic waves from a transmitter, which bounce off the water surface and return to the receiver. The time taken for the echo to return is used to calculate the distance between the sensor and the water surface. By knowing the distance, the current water level can be determined relative to the tank's total height. This method is accurate, reliable, and safe since it avoids corrosion and contamination from direct contact.

Solenoid valve

A solenoid valve is an electromechanical device used to control the flow of liquids or gases in a system. It operates using an electromagnetic solenoid coil that opens or closes the valve when energized. In water harvesting systems, solenoid valves are often used to automatically control the flow of rainwater into storage tanks. They can be integrated with sensors and microcontrollers to enable automated operation based on conditions like water level or rainfall detection. Solenoid valves are fast-acting, reliable, and come in various sizes and types depending on the fluid and pressure requirements. They typically require a DC power supply (e.g., 12V or 24V) and can be easily controlled by microcontrollers such as Arduino or ESP8266.

Blynk IoT application

A monitoring system using an ESP8266 microcontroller and the Blynk IoT application was developed to evaluate the status of plants in a hydroponics system.

Sensors collect the data, a microcontroller processes it, and the data are then transmitted to the Blynk server to be saved for further use. The user can employ that information to evaluate a plant's requirements and remotely activate the water, nutrient, or acid pump connected to the hydroponics system using the Blynk app.

The Internet of Things (IoT) is a technology that enables any device to be controlled remotely. The Blynk IoT application is an Android app that can be linked to Wi-Fi. The first step is to install the application and its libraries on a smartphone and the ESP8266 microcontroller. After creating a new account on the Blynk server through an e-mail, the smartphone can add a new device and activate the connection with the microcontroller linked to the Wi-Fi. The interface can be designed according to the requirement of the system from the libraries of the Blynk app, which has more than 40 ready-to-use UI elements such as buttons, sliders, etc. After the design is completed, the application is linked to

Wi-Fi. the shortcut of the final Blynk IoT app. Using the Blynk IoT app, the user can view the hydroponics parameters. If parameter values deviate from the required levels, the ESP8266 microcontroller can automatically activate the salt or water pumps, or the user can manually activate them via the app's interface on a smartphone.

Working Methodology

The developed hydroponics monitoring system is implemented in the field at the Palestine Technical University- Kadoorie- Tulkarm- Palestine. The proposed design has three main tanks: the first tank contains fresh water mixed with fertilizer solution, the second tank contains the mixed potassium, phosphate, and nitrogen solution and the third tank is used to store the phosphoric acid solution. The sensors employed in the developed hydroponics monitoring system are water level, temperature, TDS, and pH. These sensors are mounted in the basin. The water level sensor transmits the water level record to the ESP8266 microcontroller. If the water level drops below the predetermined level, the ESP8266 microcontroller receives data from the sensor and instructs the water pump to compensate. Meanwhile, the temperature sensor monitors the water temperature to prevent adverse consequences to the plants should the temperature drop to below 17 °C. The TDS sensor measures the salt level in the water in the basin and transfers the recorded data to the ESP8266 microcontroller. Thus, when the plant consumes a specific amount of salt, and the water's salt concentration EC falls below 1600 PPM, the ESP8266 microcontroller receives information from the TDS sensor and instructs the salt pump to compensate for the salt loss through a particular concentration from the second tank. the main flowchart of the proposed hydroponic monitoring system.

The pH sensor measures the pH level of water in the cultivated basin and directly sends the data to the ESP8266 microcontroller. Conventionally, plants require a pH degree of 6.5 to 7 in the hydroponics-cultivated basin. Therefore, if the pH rises above 7°, the ESP8266 microcontroller will instruct the acid pump to add phosphoric acid to reduce the acidity to a reasonable level the block diagram of the main structure of the developed monitoring hydroponics system.

As mentioned previously, the sensors collect high precision real-time data on the environment of the hydroponics system and send it to the ESP8266 microcontroller. The ESP8266 microcontroller analyzes the data, turns on the suitable pump, and connects to the smartphone as IoT device through Wi-Fi. The mobile application and the ESP8266 microcontroller communicate regularly with each other through IoT protocols, providing secure and efficient transportation of data between the mobile application and the IoT devices. Using a mobile application, the user provides instructions to the IoT devices to modify the relevant hydroponic environment parameters, such as the nutrient solution, water level, pH level, or temperature, within certain limits. Users can remotely check on

Results :

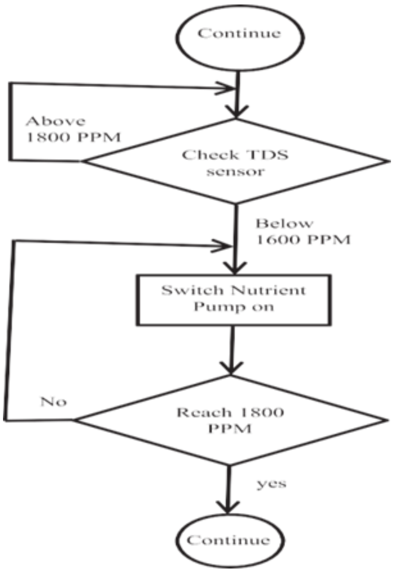
Table 1

Daily data gathered from the Blynk app.

(°C)

The hydroponic system's status is continuously monitored through a smartphone app, which receives real-time data from IoT sensors.

A fully functional prototype was developed using an ESP8266 controller and the Blynk IoT app, ensuring seamless connectivity with a smartphone. Over two weeks, daily data collection showed stable readings, except for temperature variations, which were automatically adjusted. Weekly readings taken over five weeks highlighted fluctuations in water and nutrient levels due to plant absorption, reinforcing the need for daily monitoring.



Accurate data helps maintain optimal conditions, preventing crop loss. For instance, if pH exceeds 7.5 or EC surpasses 1800 ppm, nutrient absorption is hindered, potentially harming plant growth.

This hydroponic system is adaptable for various plants, with customizable programming to regulate pH, salt levels, and temperature. In stable climates like Palestine (17°C–33°C), temperature adjustments may be minimal, but in extreme conditions, heaters or fans can be added.

Studies show pH levels in hydroponics range from 6.01 to 7.5, with our system averaging
6.8 daily. EC values vary between 1098.29 ppm and 1448.84 ppm, with our readings around 1296.96 ppm, occasionally reaching 1779 ppm. Fluctuations depend on plant type, environmental factors, and sensor accuracy.

Real-time monitoring and upgraded sensors can optimize nutrient balance, enhancing plant health and productivity in hydroponic farming.

Conclusion

This hydroponic monitoring system, built around an ESP8266 microcontroller with Wi-Fi connectivity, helps farmers automate and manage their crops efficiently. It collects real-time data from sensors measuring pH, EC, water level, and temperature, automatically adjusting water, phosphoric acid, and fertilizer pumps as needed.

For lettuce cultivation, the system maintained an average pH of 7, EC below 1800 ppm, and temperature under 27°C. The Blynk mobile app allows remote monitoring and control, making the system user-friendly and affordable. This IoT-based solution effectively enhances plant growth and simplifies hydroponic farming.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

References

[1] P Khandelwal (2014) Water harvesting in hilly area. International Journal for Scientific Research & Development 2: 852-859.

[2] N Naj, A Sanzgiri (2021) An IoT based Real-Time Monitoring of Water Quality System. Social Science Research Network https://papers.ssrn.com/sol3/papers.cfm?abstra ct_ id=3883305.

[3] Sayali Wadekar, Vinayak Vakare, Ramratan Prajapati (2016) Smart water mangement using IoT. IEEE 978-15090.

[4] J Merz, G Nakarmi, R Weingartner (2003) Potential solutions to water scarcity in the rural watersheds of Nepal's Middle Mountains," Mountain Research and Development 23: 14-18.

[5] Rupalir Shevale (2018) IOT based Real Time Water Monitoring System for Smart City. International Journal of Innovative Science and Research Technology 3: 246-251.